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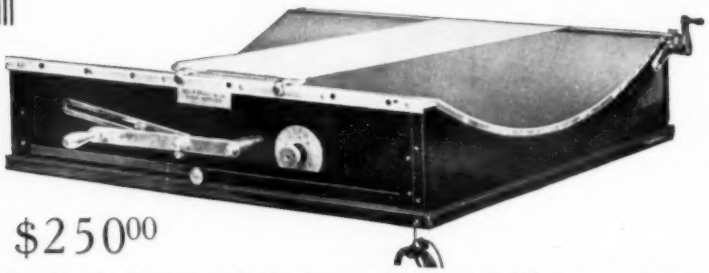

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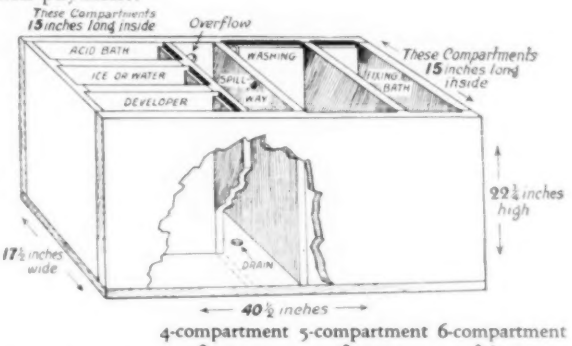

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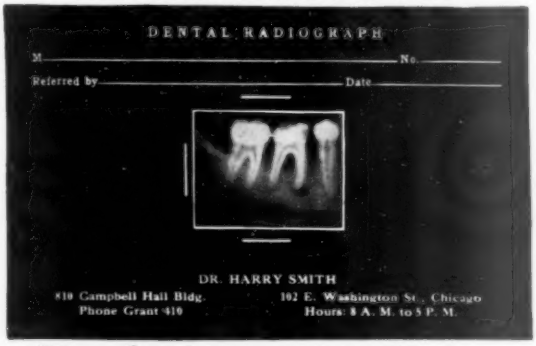

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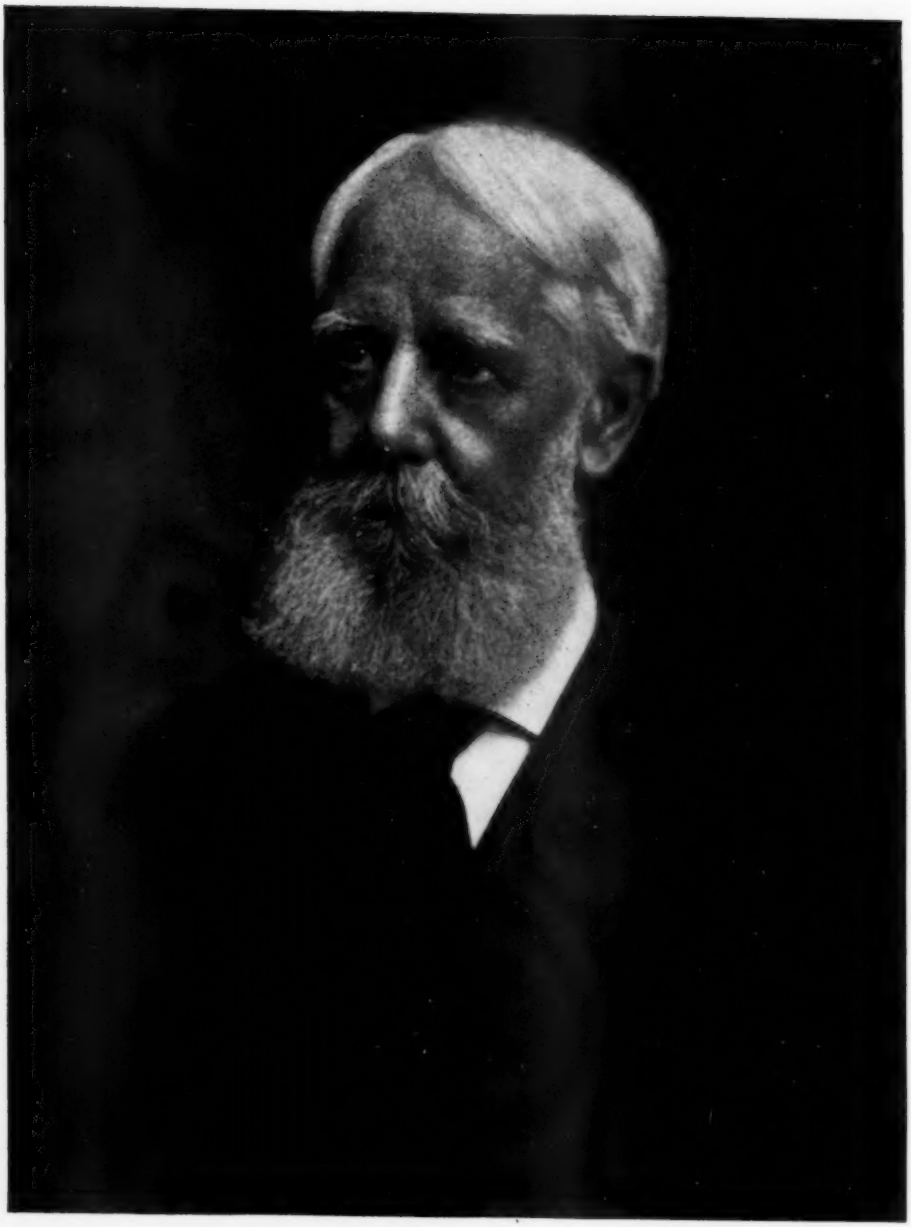

Francis H. Williams

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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ROENTGENOLOGIC DIAGNOSIS OF CHOLECYSTIC DISEASE WITH THE AID OF THE SODIUM SALT OF TETRABROMPHENOLPHTHALEIN*

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THE technic of administering sodium tetrabromphenolphthalein is essentially the same as that outlined by Graham and Cole, and by us in a recent paper. However, we have found it necessary to modify the technic in a few details, and to exclude the method altogether in certain cases.

Early in the work[1] the dye was given to several patients whose common ducts were obstructed by stone, and to one patient with partial obstruction of the head of the pancreas due to cancer. Soon after the administration of the dye these patients became ill and continued so for eight or ten hours. It was, therefore, decided that the employment of the dye was inadvisable when obstruction was known to exist.

In cases of cholecystic disease in which there was no obstruction of the hepatic or common duct the results were more gratifying, but some of these patients also experienced reactions ranging from mild to severe.

REACTIONS TO TEST

The typical severe reaction is one of vasomotor shock. It begins usually within five to ten minutes. There is first a sense of uneasiness, followed by severe pain in the region of the dorsal and lumbar spine, flushing of the skin, and a rise of from 10 to 50 mm. in blood pressure, followed within three to five minutes by a sharp fall. In one instance the systolic pressure fell to 70. Gradually, during the next fifteen to thirty minutes, the pressure returns to its previous normal level. With the fall in blood pressure, the patient may have intestinal cramps, become nauseated and vomit. The skin becomes cold. Patients may perspire freely, or have incontinence of the bowel and bladder. As several such reactions occurred under our observation we concluded that the method was unsuitable for patients with any type of cardiovascular disease, particularly arteriosclerosis and chronic cardiac disease. Patients with extreme neurotic tendencies, and those who are apprehensive, will invariably experience a degree of reaction which is annoying, although not alarming.

Because of the numerous reactions the standard dose of 5.5 gm. was reduced to 4.5 gm. The results were much more satisfactory, but not without a few disappointments. Some of the patients became flushed, had slight pain in the back, and transient nausea for from five to ten minutes. Occasionally a delayed reaction developed four or five hours after injection.

[1] Valuable assistance in these investigations was given by Drs. Waltman Walters and E. Eric Larson, of the Clinic.

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., September 3–6, 1924.

These symptoms seemed to be brought on by the patient's getting out of bed and walking about the room, or changing suddenly from a recumbent to an upright position. In the delayed reactions the nausea and vomiting gradually subsided in from one to three hours.

revealed no changes attributable to the dye.

The sodium salt of tetrabromphenolphthalein has a high molecular weight; its solution is very hypertonic, and caution must be used in giving any hypertonic solution. It is common knowledge that

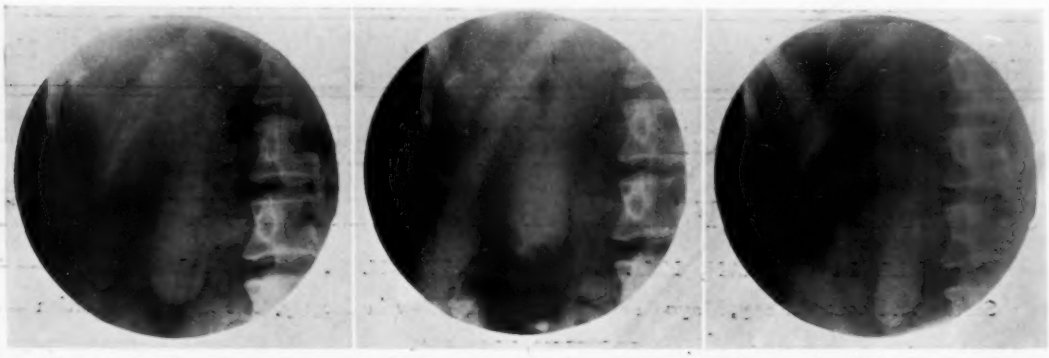

FIG. 1 (A475997). Normal response to the Graham test. Shadow of the gallbladder at the fifth, eighth and twenty-fourth hours, reading from left to right. The gallbladder is larger at the eighth hour (center) than at the fifth (left) and twenty-fourth (right) hours. The shadow is homogeneous, its density increases progressively and the contour of the gallbladder is regular.

As the reactions simulate those of vasomotor depression, we are now giving hypodermically, 10 minims of a 1:1000 solution of adrenalin chlorid, just as the blood pressure begins to rise after the initial drop. This checks the nausea and vomiting and restores the blood pressure

certain persons cannot tolerate hypertonic solutions intravenously. Our present custom is to make a provocative test by introducing 5 c.c. of the solution. If no reaction occurs after from three to five minutes, the remainder of the first dose may be administered safely. Two patients

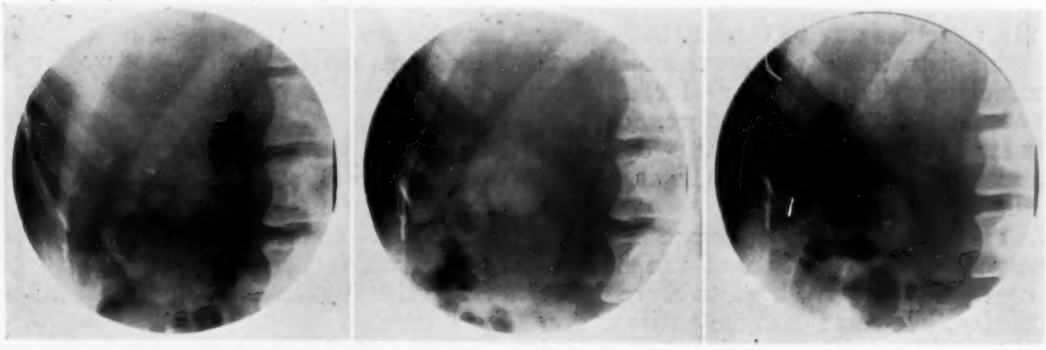

FIG. 2 (A467076). Normal response to Graham test. For description see Figure 1.

to normal. Evidently the symptoms result from lowered blood pressure following dilatation of the splanchnic vessels, and passive congestion of the liver, pancreas, spleen and stomach. With regard to unfavorable effects of the dye, it may be said that tissue, taken from the liver at operation and examined microscopically,

in our series developed severe pain in the back and abdomen after the injection of only 5 c.c. In such cases the procedure is stopped and the patient dismissed.

The reactions of the forty patients last examined are indicated in Table 1. The symptoms are graded on a scale of 0 to 4, according to their severity; no reaction is

TABLE I

REACTIONS TO SODIUM TETRABROMPHENOLPHTHALEIN IN FORTY CASES OF CHOLECYSTIC DISEASE

Case	Dose, c.c.	Degree of Reaction*	Case	Dose, c.c.	Degree of Reaction
1(A474437)	20	3	21(A474967)	40	0
2(A474237)	40	2	22(A435865)	40	1
3(A474789)	20	1	23(A475226)	40	0
4(A474539)	40	0	24(A411825)	40	1
5(A473607)	40	2	25(A475982)	20	3
6(A473406)	40	0	26(A372829)	40	1
7(A474853)	40	0	27(A121397)	40	0
8(A474854)	20	2	28(A476501)	40	0
9(A370366)	40	0	29(A475907)	40	4(after five hours)
10(A476282)	20	2	30(A473789)	40	2
11(A474769)	40	0	31(A476809)	40	0
12(A473789)	5	3	32(A93994)	40	0
13(A473749)	40	0	33(A213605)	40	0
14(A474708)	40	0	34(A477061)	20	2(urticaria)
15(A474235)	40	0	35(A109416)	40	0
16(A474666)	40	0	36(A475971)	40	0
17(A474989)	40	0	37(A475681)	40	1
18(A475442)	40	0	38(A61861)	40	0
19(A473988)	20	2	39(A478641)	40	0
20(A475472)	40	2	40(A461394)	5	3

* Degree of reaction indicated on ascending scale of 0 to 4.

SUMMARY

	Cases
No reaction	22
First degree	5
Second degree	8
Third degree	4
Fourth degree	1

graded 0, manifestations of only flushing and palpitation of the heart for a few minutes are graded 1, and severe nausea, vomiting, and a fall of blood pressure are graded 4. Intermediate phases of the reaction are graded 2 and 3. It will be noted that many of the patients had no reaction; five of the reactions were graded 1, one was graded 4, and the remainder 2 and 3.[1] If the reaction was severe, the procedure was stopped after giving the first dose of 20 c.c.

Shadows of the gallbladder, obtained following the dose of 4.5 gm., have been quite as satisfactory for diagnostic purposes as those produced by the original dose of 5.5 gm.

TECHNIC

1. The patient is hospitalized during the first twenty-four hours. No special preliminary preparation is required, but neither fluid nor food is taken after 5 a.m. of the day of examination, nor are enemas or cathartics taken.

2. Four and one-half grams of the salt is added to 40 c.c. of triple distilled water, heated slowly and stirred gently until it dissolves, which readily occurs. The mixture is then sterilized in a boiling water-bath for fifteen minutes and cooled to body temperature for use.

3. The dye is administered intravenously in two equal portions, one-half hour apart. It has been found that if the dose is divided, the second portion is better tolerated. The median basilic vein is selected whenever possible. If the cephalic vein is used, thrombosis may occur. Extreme care is taken that none of the solution gets outside of the vein, for it is very irritating. To aid in avoiding this, two syringes, one with normal saline and one with dye, should be used. After free entrance to the vein is obtained with the normal saline, the barrel of this syringe is disconnected, and the one containing the dye substituted. The injection is made slowly, consuming from five to seven minutes. Rapid administration is likely to produce toxic symptoms, and severe

[1] These clinical grades should not be confounded with the pathologic grades referred to later.

TABLE II

EXAMPLES OF NORMAL RESPONSE TO THE GRAHAM TEST

Case	Hour						Other Qualities of Shadow
	Fifth		Eighth		Twenty-fourth		
	Intensity	Size	Intensity	Size	Intensity	Size	
A470942	1*	3	2	4	4	2	Oval or pyriform, uniformly shaded, and of regular, even contour.
A468055	1	3	2	3	3	2	
A469012	1	4	2	4	3	3	None of these patients has been operated on, so that abnormalities of the gallbladder cannot wholly be excluded, but the results of the Graham test may be regarded as typically negative.
A467282	1	3	2	3	3	3	
A462830	2	3	2	4	2	2	
A467076	1	3	2	3	2	2	(In some cases deemed negative, a small but intense shadow was present as late as the thirty-second hour; more often no shadow was seen at that time.)
A370366	2	3	2	4	3	3	

* Numerals indicate intensity and size of gallbladder shadow on ascending scale of 0 to 4.

pain along the vein. Heat relieves the pain, causing it to disappear in from one to two hours.

4. Roentgenograms are made at the fifth, eighth and twenty-fourth hours, and, if desired, at the thirty-second and forty-eighth hours, after giving the dye. Roentgenograms should always be made also prior to giving the dye. When they yield positive findings, the dye-test is unnecessary.

5. The stomach and duodenum are kept as nearly empty as possible by giving only a glass of milk or a cup of tea at noon, a small amount of water in the afternoon, and a nonprotein dinner in the evening. The next morning the patient may resume his normal diet and be dismissed from the hospital.

INTERPRETATION OF FINDINGS

Points of distinction between the normal gallbladder are as follows:

Normally the gallbladder will retain sufficient dye to cast a shadow at the fourth or fifth hour after administration. This shadow attains its greatest intensity some time between the eighth and twenty-fourth hours, becomes progessively thinner thereafter, and should disappear between the twenty-fourth and forty-eighth hours. The shadow is oval or pyriform, with an even contour, and should be homogeneous. It is larger at earlier than at succeeding hours. This variation in size is important evidence of normal distensibility and contractibility (Table II).

Abnormal responses include failure of the gallbladder to fill with the dye, scanty filling as shown by persistent faintness of the shadow, delayed filling, marked delay of emptying, deformity of contour, unvarying size of the shadow, constant extremes of size, and mottling, or central defects. In the absence of cirrhosis or gross impairment of hepatic function, interference with filling suggests obstruction, due to gallstones, adhesions, new growths, thickened bile, or other pathologic conditions. Unvarying size of the shadow implies loss of elasticity of the gallbladder walls. Mottling of the shadow suggests stones or papillomas.

STATISTICAL REVIEW OF SERIES

During the last five months at the Clinic, 178 patients have been examined by the Graham method. Of these, 39 were operated on, and the essential findings are presented herewith. Eight other patients

were also operated on, but are omitted from consideration as the examination was unsatisfactory.

In Tables III and IV the intensity and size of the gallbladder shadow are demonstrated at the fifth, eighth and twenty-fourth hours; abnormalities of the shadow are noted, and the surgical and pathologic findings given. Occasionally films were made at the fifteenth, thirty-second, and forty-eighth hours, but they were rarely under suspicion, clinically, of having some disorder of the biliary tract.

For convenience of study and comparison, the 39 cases of cholecystic disease proved by operation were divided into two groups; those in which gallstones were present, and those in which there were pathologic conditions of the gallbladder, but no stones.

The gallbladder failed to fill with the dye in 19 of the 25 cases with gallstones.

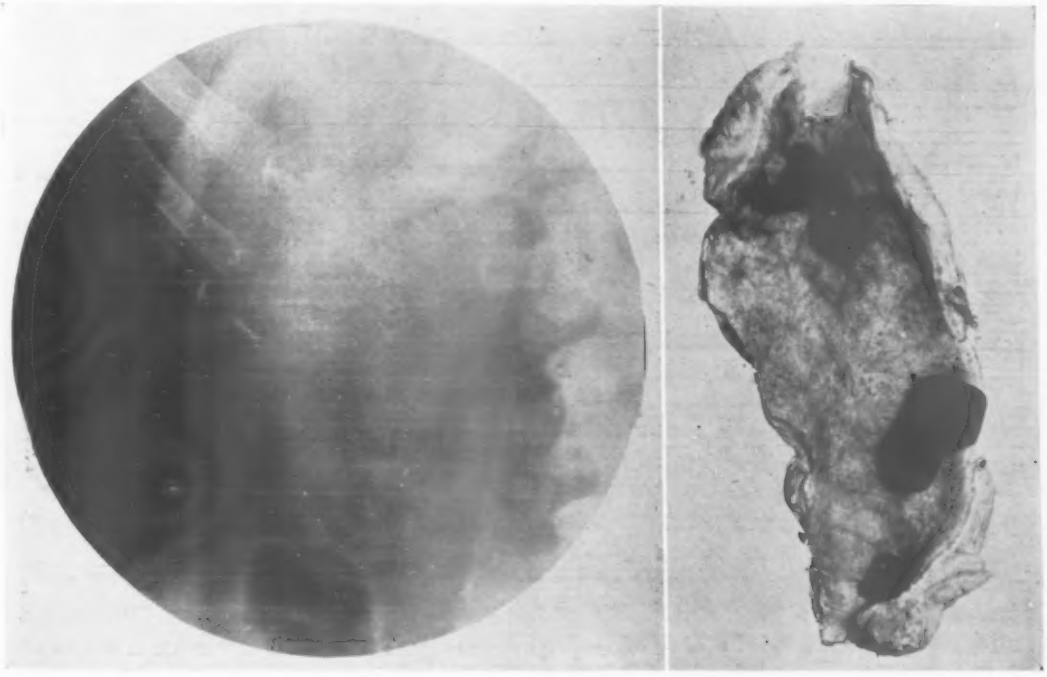

FIG. 3 (A47-0961). Gallbladder not visible. Shadows of gallstones faintly visible in original films. Photograph of specimen: Chronic cholecystitis with stones.

significant, and those made at the fifth, eighth and twenty-fourth hours seem to give sufficient information.

In the absence of both surgical and pathologic proofs, little definite information can be derived from the cases of the patients who were not submitted to operation. However, less than one-fourth of them responded normally to the Graham test. Assuming the reliability of the test and the accuracy of the technic employed, this circumstance agrees with the extraordinary frequency of cholecystic disease; and it is not surprising in view of the fact that practically all of the patients were

Shadows of the gallstones themselves were visible in 6 cases, either in the preliminary roentgenogram, or after the dye was given. Dye entered the gallbladder in 6 cases, but in 2 of these the shadow was mottled with transparencies; in one, the dense shadow of stones was seen within that of the gallbladder; and in one the gallbladder was faintly visible at the eighth hour only. Thus, in only 2 cases of the 25 could the findings be construed as negative. Obstruction of the cystic ampulla, cystic duct or hepatic duct by stones explained the failure of the dye to enter the gallbladder in 9 cases. Hepatitis was noted in 7 cases,

and this may have been a minor contributing cause. In certain instances the mere volume of the stones may have prevented the entrance of sufficient dye to outline the gallbladder. Whether spasm of the gallbladder or cystic duct, excited by the stones, was a deterring element is problematic. At all events, considering the fact that heretofore in the Clinic, a maximum of only 38 per cent of gallstones have been demonstrable by simple roentgenography, the dye rendered conspicuous service in these cases by giving

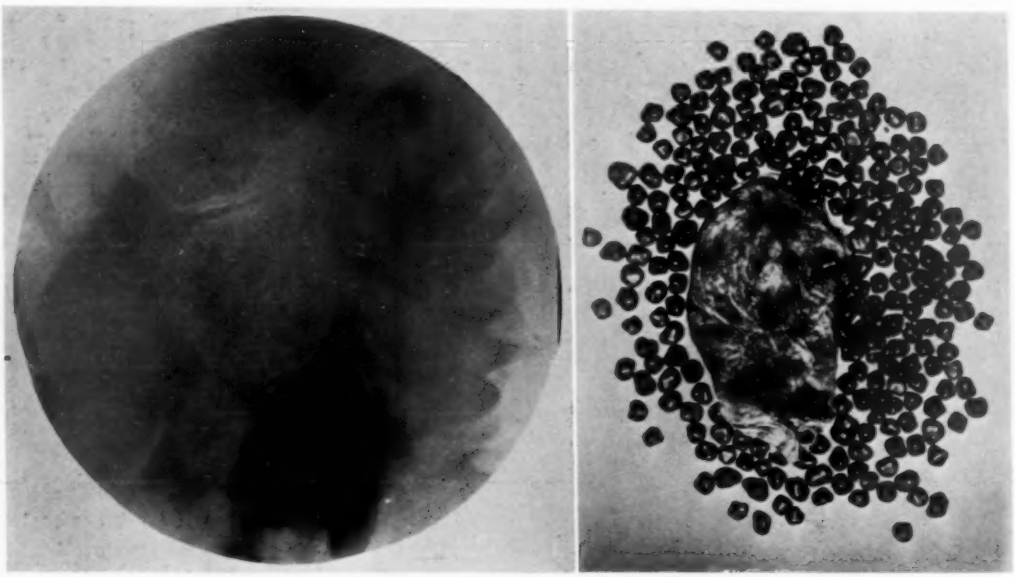

FIG. 4 (A437289). Large, mottled shadow of dye-filled gallbladder. The mottled appearance is due to a great number of stones displacing the dye. Photograph of specimen: Chronic cholecystitis; multiple small stones.

indications of a pathologic condition in all but two. Further, the dye is of value in excluding shadows due to other causes. In one case in which operation was not performed, shadows resembling those of stones appeared in the preliminary film; after the dye was given, the suspected shadows were seen to be quite unrelated to that of the gallbladder.

There were 14 cases in which there was a definite lesion of the gallbladder, but no stones. In 8 the gallbladder failed to fill with the dye. Abnormalities of filling were noted in 3 cases; the gallbladder was depicted only at the twenty-fourth hour in one of these, and in the other 2 was shown at the fifth and eighth hours only. No abnormalities of filling were observed in the remaining 3 cases. The pathologic changes in these cases, as shown in Tables III and IV, were diverse. Some of the changes, such as obstruction of the cystic duct by cancer of the pancreas, papillomas of the gallbladder, thickened walls, thickened bile, and adhesions, may have acted mechanically to prevent filling or to restrict it. It is noteworthy, however, that in the 3 cases in which the filling was normal, there were adhesions and papillomas in one case, moderately thickened bile in another, and thickened walls in the third. Definite hepatitis was mentioned by the surgeon in 3 cases.

Of the 39 patients examined and followed to operation, 34 gave definitely abnormal responses to the Graham test.

ABNORMAL FINDINGS

First in importance among abnormal findings should rank absolute failure of a visible quantity of the dye to enter the gallbladder. Obstruction of the hepatic duct, cystic duct or cystic ampulla by stones is an obvious cause, and a large volume of stones in the gallbladder would also exclude the entrance of dye in visible amounts. Stones, however, were not the sole cause

in this series. Adhesions, pressure from growths, thickened walls, thickened bile, or perhaps spasticity alone, may prevent filling. Failure of the dye to make the gallbladder visible is not necessarily pathognomonic of cholecystic disease, for grave disease of the liver, such as cirrhosis, may retard or prevent excretion of the dye. No such instance occurred in this series. Hepatitis was noted at operation in 11 cases: in 5 the gallbladder was not visualized; in 2 the filling was abnormal, and in 4 it was normal, or approximately so. Other elements entered into each case, and it is impossible to appraise the effect of the hepatitis alone. With regard to this feature, it may be mentioned that Rosenthal's recent experiments indicate that the liver has a wide "factor of safety," and extensive damage is required to impair hepatic function. Ten cases in our series, in which no roentgen-ray shadow was obtained, were tested for hepatic function with normal results.

The intensity of the shadow as shown in Tables 2, 3, and 4 varied considerably. Graham has emphasized a normal increase in intensity from the fifth to the twenty-fourth hours, due to progressive concentration of the dye. Marked and constant faintness of the shadow would imply interference with the filling process.

When the shadow of the gallbladder was present, it was homogeneous in all cases save 3, in which it was mottled by the shadows or translucencies produced by stones. In some of the cases in which operation was not performed, the shadow was also mottled, but this was due apparently to pressure by adjacent gas-distended bowel.

As expected, the size of the shadow varied, but the extremes were within

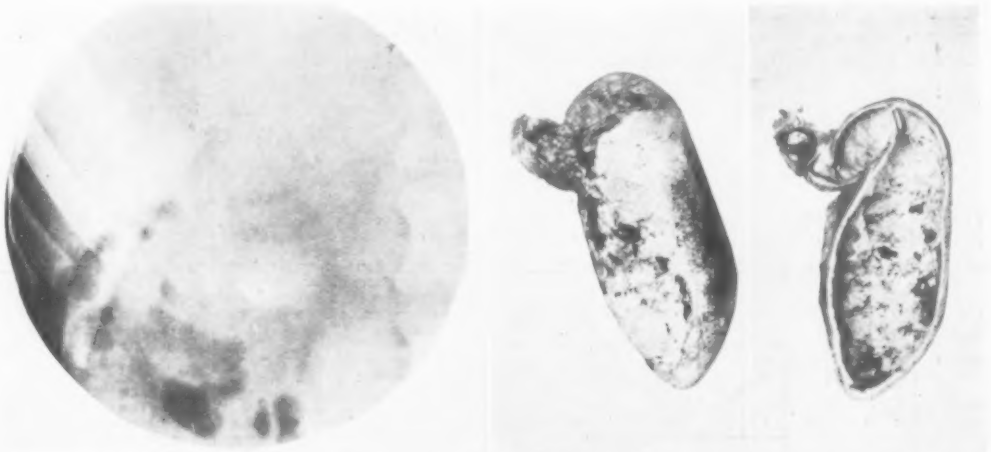

FIG. 5 (A474989). Small amount of dye in fundus of gallbladder at the twenty-fourth hour only. Photograph of specimen: Chronic cholecystitis; stone obstructing cystic duct.

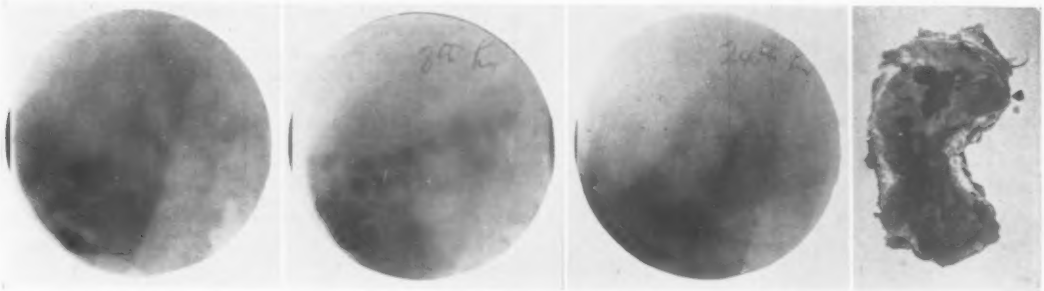

FIG. 6 (A386603). Small amount of dye in the fundus of gallbladder at the eighth hour only. Photograph of specimen: Chronic cholecystitis with stones.

TABLE III

CHOLECYSTITIS WITH STONES

Case	Hour						Additional Observations	Surgical Findings	Pathologic Findings
	Fifth		Eighth		Twenty-fourth				
	Intensity	Size	Intensity	Size	Intensity	Size			
A437289	1*	3	1	3	2	4	Mottling of shadow	Multiple stones averaging 6 mm. Hepatitis, 2	Chronic catarrhal cholecystitis with marked trabeculation
A470961	0	0	0	0	0	0		Cholecystitis with stones. Stones in common duct and hepatic duct	Subacute edematous cholecystitis. Multiple stones, largest 7 mm.
A375563							Shadow of stone in preliminary film. Gallbladder not visible at second, fourth or sixth hour after dye	Gallbladder buried in adhesions. Hepatitis, 2	Chronic catarrhal cholecystitis with thickened walls. One stone 2 by 1.5 cm. Moderately thickened bile
A472111	0	0	0	0	0	0		Stones in gallbladder ampulla, hepatic and cystic ducts. Hepatitis, 2	Cholecystitis (honeycomb gallbladder). Multiple stones, largest 1.3 cm.
A461119	0	0	0	0				One large stone in cystic duct; two impacted in ampulla. Hepatitis, 2 (cholecystostomy)	
A475226	0	0	0	0	0	0	Shadow of stone in preliminary film, visible throughout	Small contracted gallbladder with stones	Chronic catarrhal cholecystitis. Multiple stones, largest 6 mm. Thickened walls
A461572	0	0	0	0	0	0		Stones in gallbladder, cystic and common ducts. Hepatitis, 3	Chronic catarrhal cholecystitis, with marked trabeculation. Thickened fibrous walls. Multiple stones, largest 2 cm.
A464468	0	0	0	0	0	0	Not visible up to forty-eighth hour	Papillomas and one jack stone in gallbladder	Chronic catarrhal cholecystitis (papillomatosa). One jack stone
A464397	0	0	0	0	0	0	Not visible up to forty-eighth hour	Adhesions, from previous operation. Multiple stones	Chronic catarrhal cholecystitis. Multiple stones, largest 2.5 by 2 cm. Fine stony material
A464396	0	0	0	0	0	0	Not visible up to forty-eighth hour	Multiple stones. Fundus gangrenous	Chronic catarrhal cholecystitis. Stones largest 1 cm. Pericholecystitis. Contracted gallbladder
A464563	1	2	2	3	2	3	Mottling. Gallbladder still visible at forty-eighth hour	Multiple stones	Chronic catarrhal cholecystitis. (Strawberry gallbladder.) Multiple stones, largest 1 cm.
A464392	0	0	0	0	0	0	Not visible up to forty-eighth hour	Cholecystitis with stones	Chronic cholecystitis. Multiple stones, largest 1 cm. Much mucus
A465066	0	0	0	0	0	0	Not visible up to thirty-second hour	Stones in common duct. Fistula between fundus and hepatic flexure	Chronic catarrhal cholecystitis. Multiple stones, largest 2 cm.
A465644	0	0	0	0	0	0		Stones in gallbladder, common duct and hepatic duct. (Cholecystostomy)	
A466423	0	0	0	0	0	0		Gallbladder very large. Multiple stones, several in cystic duct	Chronic catarrhal cholecystitis. Early trabeculation. Multiple stones, largest 1.7 cm.
A467589	0	0	0	0	0	0		Gallbladder thick walled and buried in adhesions. Stones, one in ampulla	Chronic catarrhal cholecystitis Thickened walls. Ulceration of mucosa. Multiple stones, largest 1 cm.
A469394	0	0	0	0	0	0		Ampulla of gallbladder extremely large	Subacute on chronic catarrhal cholecystitis. Thick fibrous walls. Multiple stones, averaging 1.5 cm.
A474989	1	1	2	2	2	2		Chronic cholecystitis, 3+. Stone obstructing cystic duct	Cystic cholecystitis. One stone, 1 cm.
A476333	0	0	0	0	0	0		Small atrophic gallbladder containing stones	Chronic cholecystitis. Multiple stones, largest 7 mm.
A474235	1	3	1	3	2	3		Chronic cholecystitis with multiple small mulberry stones	Chronic catarrhal cholecystitis. Thickened walls. Multiple stones, averaging 3 mm.
A93994	1	3	2	3	1	2	Dense shadow of stone within shadow of gallbladder	Gallbladder adherent to omentum. Multiple stones	Chronic cholecystitis with trabeculation. Multiple stones, largest 2.5 cm.
A121397	0	0	0	0	0	0		Adherent thick walled gallbladder with stones	Chronic purulent cholecystitis. Honeycomb gallbladder. Multiple stones, largest 1.5 cm.
A473607	0	0	0	0	0	0	Shadow of gallstones in preliminary film, no change after dye	Chronic cholecystitis with stones. Hepatitis, 1	Chronic catarrhal cholecystitis. Thickened fibrous walls. Thickened bile. Multiple stones, largest 1 cm.
A386603	0	0	1	1	0	0	Small amount of dye in fundus only, at eighth hour	Chronic cholecystitis with stones. Hepatitis, 2	Chronic catarrhal cholecystitis. Thickened fibrous walls. Multiple stones, averaging 3 mm.
A474666	0	0	0	0	0	0		Small contracted gallbladder, stone at juncture of cystic and common ducts	Chronic catarrhal cholecystitis with trabeculation. Multiple stones, largest 1.3 cm.

* Numerals indicate intensity and size of gallbladder shadow on ascending scale of 0 to 4.

TABLE IV

CHOLECYSTITIS WITHOUT STONES

Case	Hour						Additional Observations	Surgical Findings	Pathologic Findings
	Fifth		Eighth		Twenty-fourth				
	Intensity	Size	Intensity	Size	Intensity	Size			
A471122	1*	3	2	3	2	2	Finger-like shadow	Pericholecystitis with adhesions. Definite hepatitis	Chronic catarrhal cholecystitis (papillomatosa). Multiple papillomas, largest 4 mm. Thickened bile
A460499	0	0	0	0			Not visible at tenth hour	No stones in gallbladder	Chronic catarrhal cholecystitis (papillomatosa). Thickened walls. Very thick bile
A471148	0	0	0	0	2	2	Fundus slightly flattened	Cholecystitis questionable. Hepatitis 2+	Chronic catarrhal cholecystitis. Thickened walls. Thickened bile
A457651	0	0	0	0				Biliary sinus from operation elsewhere	
A464426	2	2	2	2	1	1	No shadow at thirty-second or forty-eighth hour	Cholecystitis without stones. Hepatitis, 2	Chronic catarrhal cholecystitis (strawberry gallbladder). Thickened bile
A464917	3	4	3	4	0	0		Gallbladder bound down in adhesions. Common duct enlarged	Chronic catarrhal cholecystitis (early strawberry gallbladder)
A465098	0	0	0	0	0	0		Gallbladder enormously dilated. Cancer of head of pancreas obstructing common duct	
A465762	0	0	0	0	0	0		Gallbladder seemed normal grossly	Chronic catarrhal cholecystitis, 2. Thickened walls. Thickened bile
A467633	0	0	0	0	0	0		Pathologic gallbladder	Chronic catarrhal cholecystitis (strawberry gallbladder)
A470429	1	4	3	4	4	3		Gallbladder thick walled. Hepatitis, 1	Chronic catarrhal cholecystitis. Thickened walls
A474489	0	0	0	0	0	0		Marked cholecystitis. Large gallbladder	Chronic catarrhal cholecystitis, 4. Strawberry gallbladder. Thickened walls. Thickened bile
A192764	0	0	0	0	0	0	Not visible at forty-eighth hour	Gallbladder edematous and thick walled. Subacute infection (Cholecystostomy)	
A476517	0	0	0	0	0	0		Cholecystitis	Chronic catarrhal cholecystitis, 2. Strawberry type
A474967	1	2	1	2	0	0		Chronic cholecystitis, 2, without stones. Chronic appendicitis, 3	Chronic catarrhal cholecystitis with slightly thickened walls. Slightly thickened dirty bile

* Numerals indicate intensity and size of gallbladder shadow on ascending scale of 0 to 4.

normal limits. Graham stresses variations of size in successive films as indicating normal elasticity of the gallbladder. In a typically normal filling, the shadow is larger at the fifth or eighth hour than at the twenty-fourth. In 3 cases in this series, the shadow was undiminished at the twenty-fourth hour.

Marked peculiarity of form was observed in but one case. In this case (A471122, Table IV) the shadow was elongated and narrow, giving it a finger-like shape.

Abnormality of contour was noted in only one case (A471148, Table IV), in which the fundus was slightly flattened. Pathologic changes found at operation hardly explained the anomaly. Adhesions were present in several cases, but had no deforming effect. This, of course, does not contravene the possibility that adhesions might produce irregularities of contour.

As the gallbladder is a mobile organ its position may vary considerably without significance, and nothing extraordinary in this respect was noted in the series.

VALUE OF THE TEST

Admitting that it is still too early to draw fixed conclusions with regard to the Graham test, our experience in this series of cases nevertheless seems to warrant certain provisional opinions. The method is founded on a logical basis and promises a high degree of diagnostic efficiency. It applies the principle used so successfully in gastrointestinal diagnosis; that of giving the viscus an opportunity to fill with

a substance opaque to the roentgen ray, in order that anatomic and functional conditions may be determined visually. This feature gives the test a stronger appeal to confidence than the methods previously employed.

If the foregoing commendations are justified, certain criticisms are equally in place. In its present stage of development the test requires an elaborate technic, and occasionally the patient is made uncomfortable. It is to be hoped, therefore, that both of these objections may be overcome, that ways will be found to simplify the administration of the drug, to avoid untoward effects, and thus to make the examination easy and routinely practical.

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ABSTRACT OF DISCUSSION

Dr. Stewart, New York City, stated that he is not convinced that this method will prove of routine value but believes that, like artificial pneumoperitoneum, it will be of great value in selected cases. He is not yet certain that it is safe to declare a gallbladder pathological simply because it does not fill after intravenous injection of tetrabromphenolphthalein. He thinks that gallstones may be shown in some cases by this method when they ordinarily fail to cast a shadow. Dr. Stewart also called attention to the somewhat severe reactions noticed in a certain percentage of the cases.

Dr. P. F. Butler, Boston, reported a series of cases from which he drew the conclusion that the normal gallbladder fails to fill in a considerable percentage of cases. He also drew attention to the severity of reaction in certain cases but stated that such reaction is not now so severe since the sodium salt has replaced the calcium salt.

Dr. James T. Case, Battle Creek, Mich. I think we are very much indebted to Dr. Carman for the very exact and thorough manner in which he has presented this material. We are indebted to the clinic with which he is associated for making it possible to present so large a series, so well worked out.

Personally, I am very grateful for the facts and deductions which he has presented, which will permit us to do our work much more intelligently. I have concluded from my experience, that this test is not to be entered upon lightly. It is a test of considerable severity and it may be followed by symptoms of considerable severity. Therefore, we feel that we must really need this test as additional evidence in any case in which it is recommended.

I, fortunately, have had no delayed reactions, although all the patients who have felt like being on their feet have been allowed to go around. I have had about the same percentage of reactions as Dr. Carman, and I think about the same severity, although I have had no cases in which I have been very much alarmed. I am not sure that the second dose, in my experience, is tolerated better than the first, and I would like to know if Dr. Carman or Dr. Graham has any other reason for dividing the dose. In a number of cases I have given the entire dose at one injection and have had no greater percentage of reactions in those than where the dose was divided.

I certainly do inject slowly, and as for the technique of injection, because of a very bad abscess in the arm which I saw in a case, I made up my mind at the very beginning that the injection should be done with standard technique and in one of the minor surgery rooms where surgical technique could be followed. We give it very much as salvarsan is given, getting our needle in place first; then injecting by the gravity method a certain amount of saline solution; then putting in the dye, and then following it up with saline solution.

When I began to get my reactions, I was somewhat dismayed because I had not learned from my communications with the men already doing this work that these reactions were likely to come so frequently. However, in doing injections in connection with surgical patients, from those who had been much depleted or who suffered from serious surgical operations and needed some bolstering, I learned that the use of adrenalin was very helpful, so I began at once in these cases to inject these patients with an ampule of 1:1000 adrenalin solution, as soon as they entered the hospital and were put to bed prior to the tests. I haven't had as many reactions lately as I had formerly. We have an ampule of adrenalin ready and if we see any

cases in which this flushing of the face appears, we inject adrenalin immediately, and I am sure the attacks from the reactions are cut short in all cases and perhaps entirely eliminated in most cases.

It seems to me in discussing these cases that we would do well to talk about only those cases which have actually come to operation or to post-mortem examination. The operated, proven cases are the only ones that give us any information worth discussing, especially at this stage of our knowledge.

Dr. Camp, Boston. It is gratifying that we seem to have a method which offers such a high degree of diagnostic accuracy. I believe that this is particularly desirable because gallbladder disease seems to be so common and a condition concerning which I believe there is a great difference of opinion among roentgenologists and surgeons regarding the value of the roentgen diagnosis. I also believe by this method we will be able to check up many of our so-called direct and indirect signs. Personally, I believe that many of the shadows which are being interpreted as visible gallbladder are not visible gallbladder but are so considered later because of the fact that gallbladder disease is so common and that most pathologists seem to find pathology in the gallbladder. I think we find many of these shadows, which we thought were the gallbladder at first, to occupy quite a different position from the one which turns out to be the actual gallbladder.

Also I think it will be a great help in checking up these indirect signs such as the relation of the gallbladder to the duodenum and pressure on the duodenum.

I have had very little experience with this work; I have seen some of Dr. Carman's work, and I agree with Dr. Stewart that it is not a method to be handled as a safe routine yet. I believe it will be possible by getting a better technique and a less toxic material to use this method with great diagnostic value.

Dr. A. C. Sieford, Oakland, Calif. I would like to ask Dr. Carman whether he has found in his cases any effect of the dye upon the kidney? I refer to a toxic effect.

In talking this matter over with Dr. J. R. Oliver, associate professor of pathology at Stanford University, he told me that they had been doing some experiments on dogs and found after about two or three weeks, on autopsy, that the kidney showed very distinct lesions corresponding to a parenchymatous nephritis

I think this method is very valuable if it can be depended upon to be safe. Otherwise, the roentgenologist should not use it routinely.

Dr. Carman said, in closing, that he believed the method would assist in making visible a larger percentage of gallstones than is otherwise possible. He cited two or three cases in which in the roentgenogram made before injection the shadow of one stone was visible, while after injection ten or twelve could be counted. He stated that the reactions after the use of the sodium salt have not been so frequent or so severe as to give any anxiety. The reason that they divide the dose is to see whether the patient has any reaction from the first injection before giving the second. He has also found that in cases where reaction occurred after the first dose they have often, especially in thin patients, obtained satisfactory roentgenograms.

In reply to the question about a possible effect of the salt on the kidney Dr. Carman said that they had had no post-mortem examinations. A study of the urine, however, in these patients had shown no change.

A CLINICAL STUDY OF SOME COMMON ANATOMICAL ABNORMALITIES OF THE COLON

I. THE REDUNDANT COLON*

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CONGENITAL anomalies may be divided into three classes, namely, those incompatible with life, those compatible with life but not with health, and those compatible with life and health under reasonably favorable circumstances. In the domain of the digestive tract, the

FIG. 1. Normal colon (opaque enema).

first group may be exemplified by the condition known as congenital atresia of the bile ducts, the second group by a gastroenteroptosis of high degree, and the third by a redundant colon, which is the subject of the present paper.

The subject of congenital anomalies of the colon in general and of colonic redundancy in particular has heretofore been presented to the medical profession chiefly through the medium of such anatomical studies as those of Samson (1892), Gysi (1914), Davis (1916), and Oberndorfer (1922); the classical anatomico-clinical monograph of Curschmann (1894); and the occasional case reports of surgeons such as those of Shober (1898) and Black (1915). Such methods of approach however are unsatisfactory in that they tend to overemphasize the grave, if not fatal accidents that may sometimes occur with colonic redundancy, and thus fail to present the common everyday clinical significance of this condition. After all, what the practising physician wants to know is something about the frequency of redundant colons in life, the symptoms they may produce, if any, the manner in which they cause ill health, the means available for diagnosis, and the best methods at his disposal for treatment. The answers to these questions would seem to be best obtained by means of a combined roentgen ray and clinical study of a sufficiently large number of patients observed under the ordinary conditions of medical practice.

Material and Methods. The present study is based on an unselected series of 62 cases. These were met with in 668 consecutive private patients complaining of various gastro-intestinal symptoms, who were studied roentgenologically by the barium meal method. Of these, 145 patients had their colons further investigated by means of the opaque enema. Each one of these patients had in addition a routine gastro-intestinal study including a history, physical examination, and test meal. Although some of the cases were not followed up after the original studies were made, a good many have been kept under observation for a varying length of time up to a period of three years or more.

Definition. If a normal colon (Fig. 1) be described as one which pursues a practically straight course in following the

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classic path from cecum to rectum, a redundant colon may be defined simply as one which is too long to fit into the body of its possessor without undergoing reduplications. In terms of the yardstick such long colons are probably over two meters in length on the average, this figure being based on the careful work of Bryant, who gives the normal length in the adult as 1.5 meters, and a permissible normal variation between 1.25 and 2 meters.

FIG. 2. Redundant colon, showing pleats (mouth meal, 24 hours p.c.).

FIG. 3. Redundant colon, showing reduplications (opaque enema).

Varieties. A colonic redundancy may be expressed by simple pleats (Fig. 2) or reduplications (Fig. 3), by kinks or angulations (Fig. 4), or by loops or twists (Fig. 5). The distal colon is more frequently involved than the proximal colon. Of the various segments of the colon, the pelvic (omega, sigmoid) loop was the seat of the redundancy 27 times in my 62 redundancy cases, which makes an incidence of 4 per cent in the entire number of persons (668) examined.[1] The splenic flexure was redundant 14 times, the descending colon 11 times, the iliac colon 9 times, the transverse colon 3 times, and the distal colon as a whole 3 times. Two distinct localizations in the same case occurred 7 times (splenic and descending 3 times, splenic and pelvic twice, splenic and iliac once, pelvic and iliac once).

Three cases were met with in the series in which the pelvic colon extended well over to the right side of the pelvis, appearing to be fixed in the neighborhood of the cecum (Figs. 6 and 7). Their chief interest lies in the fact that such cases have in the past caused much confusion to surgeons during abdominal operations (Curschmann, Shober, Black).

Congenital "overdescent" or low fixation of the cecum, which may also be regarded as a form of redundant colon, was met with twice during the course of the study. These cases will not be described here further but will be reserved for a future communication.

Another abnormality that might be considered under the head of redundant colon is what might be termed a reversed splenic flexure (see Figs. 8 and 9). Normally the splenic flexure is formed by a proximal or afferent limb consisting of the

[1] These figures may be compared with those of Curschmann who found a total of 15 redundant pelvic colons (or 6 per cent) in a series of 233 bodies which he examined with this point in view.

transverse colon placed mesially and a distal or efferent limb consisting of the descending colon placed laterally and behind. Where the transverse colon is extra long it may cross over in front of the descending limb and then ascend in a lateral position, turning inward to join the descending limb which is now placed mesially. In the roentgenogram as usually taken the appearance is that of an actual crossing. This is probably not so in reality as the descending limb is placed considerably posteriorly and does not lie in the same lateral plane. Moreover, there is usually no difficulty in evacuating such reverse splenic loops after a barium enema nor do they invariably seem to cause constipation clinically. However it is possible that such a condition may under certain favorable circumstances serve as a basis for obstruction or volvulus. Eleven

FIG. 4. Redundant colon, showing kink (angulation) (opaque enema). Case VI.

cases of this condition were encountered in the total 668 roentgen-rayed cases but only those were included in the present series that were associated with other more marked redundancies.

Finally, it may be pointed out that the position of the redundant loops, as revealed by roentgen examination, is not necessarily fixed or constant. This can be seen from a comparison of Figures 10 and 12. These figures represent the findings in a case which was re-examined after a month's interval. The long pelvic loop reaching to the left hypochondrium in the first film is seen to have fallen completely into the pelvis by the time of the second observation.

Incidence. The actual incidence, that is, the incidence among the population at large, of such a congenital anomaly as redundant colon can hardly be obtained from any form of clinical experience. To get really reliable figures in this respect we must fall back on careful post-mortem studies, such as those of Bryant, who found elongated (redundant) colons in 14 per cent of 242 subjects examined. Bryant's

FIG. 5. Redundant colon, showing loop in descending portion (opaque enema).

cadavers were of both sexes and included 45 fetal cases, 37 children, and 160 adults. In my own unselected series of 668 roentgen-rayed patients complaining of various digestive symptoms, the condition of redundant colon was met with 62 times giving an incidence of 9.2 per cent. This figure is probably somewhat low, as in a few cases where the large bowel was not thoroughly studied the condition was reported as absent. There still remains however a rather large discrepancy between the deadhouse (absolute) incidence and the roentgen-ray (clinical) incidence. This discrepancy—assuming that both series

FIG. 6. Pelvic colon extending over to right side of pelvis (opaque enema).

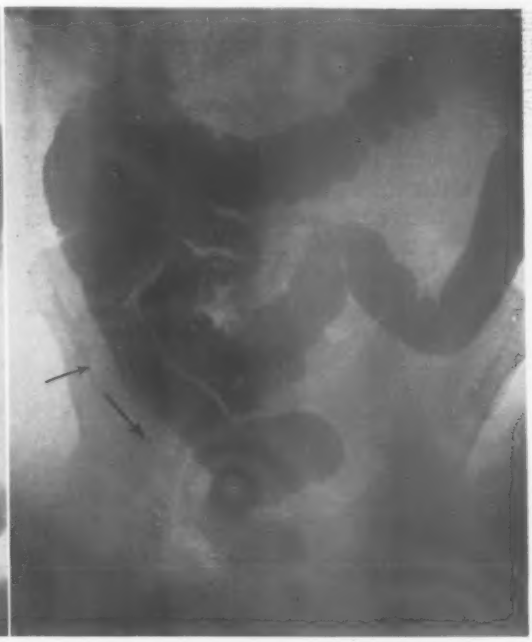

FIG. 7. Pelvic colon extending over to right side of pelvis (opaque enema).

FIG. 8. Reversed splenic flexure (opaque enema).

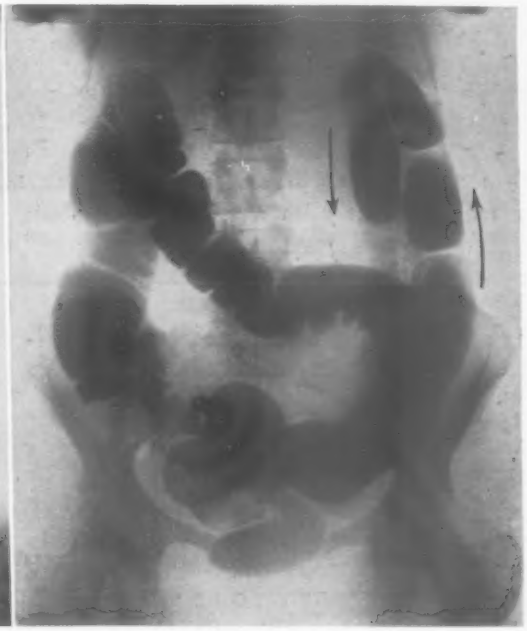

FIG. 9. Reversed splenic flexure (opaque enema). Case II.

are large enough for statistics of value—can best be explained by the assumption that many cases of redundant colon (perhaps two-fifths of the whole number) do not give symptoms during life. This opinion is further strengthened by a comparison of my figures (for pelvic colon redundancy alone) with those of Curschmann in which exactly the same discrepancy is found (see above under *Varieties*).

Redundant colon is probably hereditary and familial in its transmission though my data in regard to this point are insufficient to make a positive statement at this time.

So much for the general incidence of redundant colon. The incidence of this condition among constipated patients is of great clinical interest and importance. I have found this to be 22.9 per cent. In other words between one-fifth and one-fourth of all persons with constipation have redundant colons. The other side of the picture, namely, the frequency of constipation in patients with redundant colons will be discussed in detail later.

As regards sex distribution, only 24, or 38 per cent, of my patients were females. This is of interest because the impression may be current that redundant colon is an affliction favoring the feminine sex. Such an impression might arise from the fact that possibly most cases seen by surgeons have occurred in women—the laparotomized sex. It was also surprising to note that the condition was not associated with general visceroptosis. It occurred 34 times (54.8 per cent) in persons of a distinct sthenic (stocky) habitus, and only 19 times (30 per cent) in persons of a distinct asthenic (slim) build. The remaining 9 cases occurred in persons of intermediate stature.

FIG. 10. Redundant colon showing double splenic flexure and long straight efferent pelvic loop (opaque enema). Case III. See Figs. 11 and 12.

FIG. 11. Redundant colon showing double splenic flexure and long straight efferent pelvic loop (opaque enema showing retention after bowels moved). Case III. See Figs. 10 and 12.

Thirteen patients, or 20 per cent, had had previous laparotomies, 10 of them for appendicitis.

Symptoms: General consideration. Undoubtedly some persons with redundant colons have no symptoms whatever; others, on the contrary, may have trouble all the time; still others may be free from manifestations for years and then develop

either continued symptoms or some more or less acute and urgent syndrome. It seems a safe generalization, however, that all persons afflicted with this condition have an underlying *predisposition to colon malfunction*. Although this predisposition may not become manifest under the ordinary favorable conditions of existence, it does attract attention as soon as the subject is exposed to strain, wasting disease, or trauma such as operation or childbirth. In other words, the general tendency is for the organism as a whole to compensate for the presence of congenital deformity. It is only when this compensation breaks that symptoms arise. The common exciting causes of bowel decompensation have just been mentioned. Underlying contributory causes are improper diet, bad hygiene, and vicious bowel habit formation. Constipation is the most prevalent expression of bowel decompensation. The ordinary pathologic physiology of constipation, viz., an interplay of spasticity and atony, with a predominance of the former, is likewise operative in redundant colon, but instead of involving almost the entire large intestine as it so often does in simple constipation, it is limited to that part of the colon at the site of the redundancy. One should be careful, however, to avoid thinking of a loop as a fixed or static condition like an organic lesion. After all, a redundancy is not a barrier or stricture. It merely tends to become such when it is overfilled or displaced or distorted and it is only as long as such conditions obtain that symptoms are present. In short we are dealing with neither an organic nor with a functional condition pure and simple but rather with a combination of both, a sort of dual entity that seems to be characteristic of congenital malformations of the digestive tract in general. Such a concept as this helps us to understand how a condition present since birth may become responsible for the development of symptoms many years later.

FIG. 12. Redundant colon (opaque enema). Same case as Figs. 10 and 11, one month later.

FIG. 13. Constipation of high degree due to redundant pelvic colon. Case 1. Film taken 144 hours after mouth meal (See Fig. 14).

Constipation. Forty-eight, or 77.4 per cent, of the 62 patients in the present series complained of constipation. In most instances the constipation was a matter of long standing, dating as far back as the patients could remember. As a rule, the more marked the looping the greater the constipation. Conversely, of the three

patients with long straight pelvic loops fixed to the right, only one was constipated.

Not infrequently constipation was so much taken for granted by the invalid that he or she would forget to mention it among his complaints. It seems worth while to stress this in connection with history-taking because this important item may be completely overlooked unless it is specifically asked for. It may also be pointed out that some patients have a misleading way of saying that their bowels move daily without adding the fact that they resort nightly to cathartics.

The constipation may be very marked. Seven of my cases would go a week or more without a bowel movement, eight others would go 4 to 6 days, and eleven others 3 days; making a total of twenty-six patients who would skip as many as 3 or more days between bowel movements. This long stool interval is a very characteristic clinical feature of redundant colon. Most of these patients experienced no progressive increase in discomfort proportionate to the number of days elapsed without a bowel movement. As a rule they waited, without interfering, for a spontaneous evacuation. Others, however, especially the most neurotic ones would complain of symptoms, usually "loginess," stuffiness, headache, etc., after a day or two of constipation, and would take cathartics or enemas with increasing frequency, ultimately developing a full-blown cathartic or enema habit. In many instances such measures gradually lost their effect as the patients became used to them and even drastic purges in large doses seemed powerless to produce an evacuation. One patient reported, with mingled surprise and consternation, that she had recently taken a half glass of castor oil without any result whatever. In this case we were obviously dealing with an almost complete bowel decompensation.

Enemas were less popular home remedies, possibly because they are more troublesome to carry out than it is to take a pill. Not infrequently patients would say that the enema was inefficient because "the water would be lost within me and fail to return." This feature is almost sufficient to differentiate constipation due to redundant colon from that due to dyschezia, for example, where enemata are invariably helpful.

The danger of long-continued cathartic or enema habits is that they lead in time to still further bowel decompensation with increase of spastic and atonic phenomena. Irritation of the colon is produced with increased mucus formation, the passage of mucus being commonly complained of in all "chronic bowel cases." In some instances fits of diarrhea would alternate with the constipation (see below).

The stools were usually small, hard, and composed of scyballous masses. At intervals however, there were in many cases, copious spontaneous movements. These would appear to be due to a sudden unloading of a large mass of accumulated feces stored in an enormously distended loop of sigmoid,—so-called megasigmoid.

Case 1. Physician, aged forty-five. All his life constipated and subject to cathartic and enema habits. Previously diagnosed duodenal ulcer and had appendix removed because of atypical, recurrent abdominal pains. Within past four years subject to attacks of severe abdominal cramps and flatulence. The cramps were localized chiefly in right lower quadrant but would radiate thence across the course of the colon. Constipation severe up to a week at a time when would have an enormous evacuation which "would fill the hopper." The gas would trouble patient more than the constipation and would force him to take as many as ten enemas in succession. At times would feel comfortable when constipated but would have severe pains after a big stool.

Roentgen examination after barium meal by mouth showed a high degree of colonic stasis. On one occasion the colon was observed for 192 hours (eight days). One spontaneous stool took place at 72 hours. There were no more spontaneous stools. By 192 hours the patient had taken two oil injections and the bowels had moved three times in all. Despite this there was a very heavy residue still present in the transverse colon. On another occasion the barium meal was followed for 240 hours (10 days). By this time two stools had occurred but there were still traces of barium in the colon.

Colon enema revealed a rather small but tight figure-of-eight loop in the pelvic colon. The symptoms were interpreted as being due to intermittent overloading and unloading of the pelvic colon with spasm proximal to the loop. It was further assumed that loading the loop

in some way untwisted the figure-eight whereas evacuation twisted it tighter, thus explaining the increase in pain after copious elimination (Figs. 13 and 14).

Gas Distress. Gas distress was almost as common as constipation, the incidence being 72.2 per cent (45 cases out of 62). A brief consideration of the essential nature of this symptom may be in place at this point. During the course of normal digestion gases such as carbon dioxide, methane, hydrogen, and nitrogen, are present in the intestine. Under ordinary circumstances, the less absorbable of these gases, such as nitrogen and hydrogen and H_2S are passed per rectum; while the others, such as CO_2, and to a less extent, CH_4, are absorbed into the circulating blood and are excreted through the expired air. It is believed that whereas about one liter of gas is passed daily per rectum by a normal man on a light mixed diet (Fries), far larger amounts of the intestinal gases are absorbed into the blood and are thus disposed of (Kato). When intestinal physiology is normal we are quite undisturbed by the excretion of gas through either of the above channels. It is only when there is some interference with the processes just described that we become conscious of the presence of wind even in very small quantities. This interference may of course take the form of a gross hindrance to the onward passage of flatus such as occurs with intestinal obstruction from any cause and produces the familiar gas pains or colic. There is however another reason for gas accumulation, namely, interference with the intestinal blood supply in such a way as to hinder free and rapid absorption. This is particularly likely to occur in redundant colons with their accompanying long mesenteries in which slight twists or kinks may partly or completely shut off either the arterial or the venous blood flow or both together. In this sense gas distress may become a very delicate and early indication of bowel decompensation.

Clinically gas distress may be manifested in three ways. (1) There may be flatulence, manifested either by increased gas movement, borborygmi, or by increased passage of flatus. (2) There may be actual abdominal distention, marked by difficulty in moving the gas, which may be constant or intermittent (Fig. 15). (3) There may be belching. The belching in these cases is an irritative phenomenon really unproductive of much relief since it represents a misdirected effort on the part of the patient to rid himself of the gas in the splenic flexure. Such an accumulation of gas is illustrated in Figure 16. It is by no means an uncommon roentgen finding in patients with redundant colon.

FIG. 14. Figure-of-eight loop of pelvic colon responsible for constipation in preceding case (opaque enema). Case 1.

A particularly interesting point in regard to gas distress is that the accumulation under the left diaphragm may affect the heart function in the way of producing precordial pain and palpitation. This may occur in persons with or without organic heart lesions. It is important to learn to recognize the rôle played by redundant colons in such cases because the symptoms complained of may be immensely relieved or even completely cured as soon as the proper treatment is instituted.

Pain and Localized Discomfort. Pain was complained of in more than half (36, or 58 per cent) of the cases. It varied in

intensity from a mild discomfort to a very severe colic. In some cases it was rather general in its distribution, involving the whole abdomen or following almost the entire length of the colon. In other cases especially in those with kinks rather than with loops, it was sharply localized, being referred to the exact site of the abnormality with surprising accuracy. The pain or discomfort would often be increased by

FIG. 15. Gas caught in loop of redundant colon (24 hours after mouth meal).

activity such as walking, or by lying in a certain posture.

CASE II. Young married woman, perfectly well in the past. No constipation. One day, while placing some heavy jars on a shelf at the height of her head, she suddenly felt something break or turn over in the left side of her abdomen. The sensation frightened, rather than hurt her. Following this, she felt a weight, and thought she could make out a lump in that region. Although nothing could be discovered on physical examination except a general visceroptosis, a barium enema of the colon revealed a low-placed but very long splenic flexure with a reverse loop (Fig. 9). On closer questioning the patient admitted that she could never lie on her left side without discomfort and that on frequent occasions in the past she had experienced severe abdominal cramps in the lower abdomen which were immediately relieved on the passage of stool and gas.

In at least seven cases in this series there were sharply localized pains in the left side of the abdomen. In all such instances the seat of the pain corresponded to the location of the redundant loop or kink in the colon (Fig. 4). The pain may suggest a diagnosis of diverticulitis or new growth.

FIG. 16. Gas in distal colon in a case of redundant splenic and pelvic colon. Appearance immediately after mouth meal. Note displacement of stomach to the right (and down?).

It is practically always due to superimposed, localized spasm (Fig. 17). Right sided abdominal pain was less often complained of. In such cases the symptoms may resemble appendix or gall-bladder disease. The differential diagnosis will be considered later.

Diarrhea. Diarrhea occurred 16 times, or in 25 per cent of the cases. It was, as a rule, associated with constipation, or else it would alternate with periods of constipation. It is probably due to colitis brought on by irritation of intestinal mucosa either by retained feces or by violent cathartics.

Mucus was not infrequently present in the stools, but blood (ulceration) was absent. However, one case of right sided pelvic colon (see above) had a decided ulcerative process (ulcerative colitis) in the lowermost part of the pelvic loop (Fig. 7).

Vomiting. Vomiting occurred 14 times (22.5 per cent). It is perhaps best regarded as due to a reversal of the "intestinal gradient." As Alvarez puts it, "many of the symptoms of constipation are due simply to the plugging of the lower end of

FIG. 17. Kink (angulation) with localized colon spasm.

the canal, which slows or stops the downward current and often produces ripples of reverse peristalsis. The food cannot go downward, so the bowel tries to refuse it admittance or sends it back again." It may be of interest, parenthetically to point out that vomiting is not nearly so prominent a feature in the redundant colon cases as it seems to be in those with low fixed ceca.

CASE III. Male, aged fifty-five. Constipated up to a week at a time. No vomiting for first two or three days of constipation, but after this free interval is over vomiting would set in and continue until the bowels were emptied. Roentgen examination (Figs. 10 and 11) showed very large straight pelvic loop reaching to left hypochondrium causing a double splenic flexure. The description of the opaque enema, administered under roentgenoscopic control follows:

"Enema flows up through a straight, mesially placed pelvic colon to the left hypochondrium where it turns sharply to the left and downward parallel and lateral to the course it has just pursued, to the level of the true pelvis. It then turns back on itself, presumably in an anterior plane and reaches the normal position of the splenic flexure whence it crosses to the right side of the abdomen in the usual fashion. Evacuation of the enema after bowel movement

FIG. 18. Redundant colon showing double splenic flexure and long straight efferent pelvic loop (opaque enema). Case IV.

was very incomplete, there being a large retention throughout the entire colon proximal to the beginning of the straight efferent pelvic loop."

The configuration of the colon above described was met with three times in all in the present series (Figs. 10, 18, and 19). However the position of the loops was not fixed in the above case as is seen from a repetition of the opaque enema (see Fig. 12) whch shows the topography one month after the original study was made (see also section on *Varieties*).

Volvulus. Volvulus is an acute abdominal condition which occurs only in persons with redundant colons. Curschmann found

this to be true for every case of volvulus that he was able to examine anatomically. For example, two of his cases gave a colon length of 280 cm., one of 270 cm., six varied between 230 and 260 cm. The shortest length was 207 cm. The part of the large bowel most commonly involved is the pelvic portion. The cause of the twist is generally assumed to be an overloading of the redundant loop with feces, so that constipation is always a contributing factor. Likewise gas accumulations, as pointed out by some authors, may lift a redundant loop from its usual position and thus aid rotation and occlusion. Another factor that may, under certain circumstances, actually precipitate a volvulus, is the use of violent cathartics or purges in patients endowed with redundant colons. This possibility, it seems to me, has not been sufficiently emphasized in discussions of this subject, and yet a moment's consideration would reveal at least the theoretical danger of actually "tying in knots" the atypically placed loops of an elongated bowel driven into paroxysms of artificially stimulated, irregular peristalsis. When it is remembered that the ineffectual catharsis often leads to colonic atony with increased flatulence and meteorism it would seem that all the conditions favoring bowel occlusion through rotation would be present under such circumstances. In short there appears good reason to regard the use of cathartics in redundant colons as not only unnecessary but actually dangerous.

Only one of the writer's cases gave a past history of having had a volvulus for which she had been operated on. Unfortunately a barium enema study of the colon was not made in this case so it was not included in the present series. None of the cases in the series developed a volvulus while under observation.

Diagnosis. The diagnosis of redundant colon may be made tentatively from the history, the salient features being: (1) Long duration of constipation, the condition often dating back to childhood; (2) long interval between stools; (3) occasional enormous evacuations; (4) volvulus. Physical examination does not aid in the diagnosis. A positive diagnosis can be made only by roentgen examination. To make the roentgen study complete both the opaque meal and the opaque enema methods must be employed. Whenever possible the barium meal should be followed in its progress through the colon until the colon is empty. It is a mistake to think that a colon enema alone suffices to give all the information desirable in a study of redundant colon. It is true that the shape and position of the loops is best visualized by this method, but what the loops do to produce constipation, i.e., to make the patient sick, is by no means always revealed in this manner. Not infrequently loops which are evacuated immediately and completely on moving the bowels after the opaque enema are capable of causing such interference with the normal progress of food through the intestines as to cause a stasis of a week or more. This can be seen from a study of Figures 13, 14, 21, and 22.

Differential Diagnosis. It should be recognized that it is not the mere presence of redundant loops that causes discomfort to the patient. It is rather the associated intestinal spasm, atony, constipation—in short the secondary colonic malfunction—that brings on the symptoms. When these symptoms affect the colon as a whole the diagnosis is not so difficult; it is when they are more localized to one particular part of the abdomen that confusion may arise. Under such circumstances redundant colon must be differentiated from appendicitis, gall-bladder disease, heart disease, and cancer of the large intestine.

I have elsewhere discussed at some length the question of pseudo-appendicitis. It was there pointed out how anything operating to interfere with the progress of stool through the distal colon, be it redundancy, spasm, inflammation, or new growth, causes a throw-back of the fecal column to the right or blind end of the colon (cecum), with reference of the symptoms (pain, weight, drag, and heaviness) to the right lower quadrant of the abdomen. The same thing is true of the right upper quadrant. If a receptive hepatic flexure for some reason takes up the back-fire, the symptoms will be referred there and may be mistaken for evidence of biliary disease. Colon colic,

in such a case, would have the same distribution so far as pain radiation is concerned, as would gall stone colic. Unfortunately this point seems not to be universally known, and pains originating in the right upper quadrant are only too likely to be put down as gall-bladder trouble.

Case iv. Barber, aged forty-eight, came under observation December, 1923, complaining of abdominal pains. One year ago he had an attack of heart burn and vomiting which lasted for a week. Following this, for about two months, there were frequent abdominal cramps, as a rule

Roentgen examination (Fig. 18) showed an enormous efferent pelvic limb extending to the left hypochondrium, as well as a complete loop in the region of the descending and iliac colon. The condition was very similar to that represented in Figures 10 and 19.

Course. Oil injections were ordered nightly for one month and then mineral oil by mouth. His diet was regulated and his water drinking increased. At intervals he was put on belladonna. Re-examination 6 months later showed that the bowels were moving spontaneously once or twice daily, and that there had been no recurrence of pain or vomiting.

Fig. 19. Redundant colon showing double splenic flexure and long straight efferent pelvic loop (opaque enema). Case v. See Fig. 20.

Fig. 20. Same case as Figure 19, showing retention after bowels moved.

general in distribution, but often localized more on the right side. A diagnosis of gastric ulcer was made by his doctor and the patient was put to bed. He then remained free from symptoms until one month ago when the pains returned as before. This time a diagnosis of gall-bladder disease was made by another physician and the patient was advised to undergo operation.

On further questioning it was brought out that the patient had been constipated for the past 25 years. At times there were free intervals, lasting up to two months at a stretch, when the bowels would move spontaneously every day. Otherwise the patient had been taking cathartics or enemas, twice a week, on the average.

Redundant colon may of course accompany gall bladder disease. In such cases however, therapy directed solely toward the bowel condition may satisfactorily control the biliary symptoms as illustrated in the following instance.

Case v. Female, aged fifty-seven, married, came under observation March 7, 1924. She had had five distinct attacks of gall stone colic. The first three came on two years apart from 1918 to 1922. The last two came much closer together, the fourth occurring in December, 1923 and the fifth on February 7, 1924. The patient said that 30 years ago she lifted a heavy object and felt something "give" inside her

abdomen. Since that time she had been constipated. Six years ago the constipation became worse and it was at this time that the attacks of gall stone colic began. For the past year the patient has been taking an enema every other day in order to avoid if possible a recurrence of the painful seizures.

Roentgen examination revealed the presence of 6 to 8 gall stone shadows along the liver margin corresponding to the position of the gall bladder. After the barium meal by mouth the colon failed to empty within 72 hours, a residue being present at that time despite 3 stools in the meanwhile. The enema (Fig. 19) revealed a long efferent pelvic loop forming a double splenic flexure and resembling very closely the findings in Cases III and IV. The evacuation of the barium enema was very poor, a large residue remaining proximal to the point of redundancy (Fig. 20).

Course. The patient was put on routine treatment for the restoration of bowel function. Oil injections were prescribed, at first nightly, and then at longer intervals as needed. On July 1, 1924 the patient reported that she had recently had two mild attacks, lasting 15 minutes each and that she was using the oil injections once a week which kept her bowels moving regularly.

It has already been shown that acute attacks of gas colic, particularly when involving the splenic flexure may cause embarrassment of heart action. Under such circumstances a mistaken diagnosis of organic heart trouble is not uncommon. In one case seen by the author a diagnosis of angina pectoris was made on account of the pain distribution and a bad prognosis was given by an eminent clinician. The patient improved under therapy directed toward restoration of the bowel function and is alive today (one year later).

Redundant colon may resemble cancer of the large intestine in those cases where increasing intervals between bowel movements suggest beginning intestinal obstruction. This is particularly likely to be the case when the symptoms first come on or become prominent in persons of the cancer age. The following case is of interest in this connection.

CASE VI. Physician, aged seventy, came under observation February 25, 1922. He gave a history of long standing attacks of right sided abdominal pain, diagnosed gall-bladder disease, and of precordial distress, diagnosed angina pectoris.

Six months ago he observed onset of insufficient bowel movements. The stool began to come in installments and the patient had to strain considerably to get the scybala out. There developed a soreness deep in the left iliac fossa which had been constant for the past week. The doctor feared that he was suffering from a carcinoma of the descending colon.

Barium enema showed a definite kink (angulation) (Fig. 4) at the junction of the descending and iliac colons with considerable spasticity of the distal colon. This was confirmed on two subsequent examinations, several months apart, and again one week ago.

The treatment outlined consisted chiefly of mineral oil and belladonna. The patient improved and is fairly comfortable today (August, 1924), more than two years later, with only occasional recurrence of the spastic manifestations.

Therapy. The secret of successful therapy in colonic redundancy can be summed up in two propositions: first, restore colon function, then leave the bowel alone. No matter how bad a mistake nature seems to have made very little can be hoped for from aggressive human interference. This is exemplified by the unsatisfactory results of surgical treatment in these cases. Patients with redundant colons often suffer more from their own ill-advised interference than they do from the underlying condition. It has already been shown how bowel competence is impaired by vicious cathartic and enema habits. The first step in the treatment of the resulting increased constipation is the withdrawal of such irritating practices. The further management of the condition does not differ essentially from the general treatment of constipation as elsewhere described by the author. Suffice it here to say that a rough, bulky diet seems best suited to stimulate effective peristalsis and that forced water drinking is necessary to prevent undue drying of the feces. Lubrication from above and below is almost always necessary and helps particularly to overcome the associated spasm. To this end mineral oil by mouth, best given after each meal, and large injections—6 to 8 ounces—of Mazola oil by rectum to be retained preferably overnight, are the

best procedures. Belladonna in increasing doses (10 to 25 drops three times a day) may also be required where the spastic tendency is excessive. Rest of body and mind, and general sedatives here as elsewhere in constipation have an important place in the therapy. In these cases it is not necessary for the bowels to move every day, since a reasonably competent colon will make up for an absent stool one day by a larger output on the succeeding one.

Once colon function is restored, a redundant bowel may be subjected to considerable demands, such as those associated with a major pelvic operation, and still come out with flying colors. This is brilliantly illustrated in the following example.

CASE VII. Female, aged thirty-five, married. Constipation since childhood. Maximum stool interval 5 days. Cathartic habit for 12 years, nightly for past 8 years. At times cathartics fail. Has taken one-half glass castor oil without result. When constipated abdomen becomes distended and she has pain in the left lower quadrant. It is difficult to pass gas but if she does, relief follows.

The barium meal was followed for 150 hours (about 6 days), three small stools having occurred after the third day. When the examination was discontinued (150 hours) a large residue was still present in the colon (Fig. 21). A barium enema revealed a very long looped pelvic colon (Fig. 22).

The patient was then put on routine dietetic management with the result that in the next three months she had on the average 4 to 5 spontaneous stools a week. She was then put on increasing doses of tr. belladonna (15 to 30 drops three times a day) with a further improvement to 6 spontaneous stools weekly.

FIG. 21. Constipation of high degree due to markedly redundant pelvic colon. Case VII. Film taken 155 hours after mouth meal. See next figure. Knuckle of loop filled with barium (arrow).

FIG. 22. Redundant pelvic colon (opaque enema) responsible for constipation in preceding case. (Case VII; Fig. 21.) The descending colon was not visualized at the moment the film was taken.

At about this time it was discovered that the patient had an ovarian tumor and laparotomy was decided upon. In consultation with her surgeon, Dr. A. Unger, it was agreed to suspend all preoperative "treatment" of the bowel. A large sarcoma of the right ovary was successfully removed. Following the intervention the patient's bowels did not move for seven days during which time she had no digestive symptoms whatever—no vomiting, nausea, regurgitation, distention or gas pains. On the eighth day an oil enema was given with good results following which the bowels resumed the same degree of competence that they had attained before the operation.

SUMMARY

Congenital anomalies of the colon, such as redundancy, have heretofore been largely the concern of the anatomist and the surgeon. The clinical significance of these malformations is the subject of the present study which is based on 62 cases in a series of 668 gastrointestinal roentgen examinations. Redundant colon is by no means a rare anomaly It occurs in from 9 to 14 per cent of all persons and in 23 per cent of al constipated individuals. It is more common in sthenics than in asthenics, and in men than in women.

Symptoms are brought on by strain or injury or by abuse of colon function Redundant loops are in themselves not necessarily obstructive to the passage of feces, but may become so under certain conditions of localized stasis or sudden changes in posture with or without interference of the blood supply. Perhaps two-fifths of all cases of redundant colon show no symptoms.

Constipation and gas distress are the most common symptoms. Pain is almost as common. Volvulus, though rare, considering the frequency of the condition, occurs only in redundant bowels.

The diagnosis is made by roentgen examination. The differential diagnosis is from gall-bladder disease, appendicitis, colon cancer, and cardiovascular disease.

The therapy consists in restoration of colon function where this is decompensated, and otherwise in non-interference. Vicious cathartic and enema habits should be discontinued. Spasticity should be overcome by rest, lubrication and anti-spasmodics. Surgery is not indicated for redundancy as such and should be reserved for superimposed accidents such as twists or torsions.

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DISCUSSION

DR. FRANKLIN WHITE, Boston. This is an important subject and I think we are very much indebted to Dr. Kantor for this combined clinical and roentgen study; all the more so because this is a subject which is not very much mentioned in detail in the textbooks; it is not an easy subject to look up. There are some valuable papers, but our systems of medicine say very little about it, and it is barely referred to as the cause of constipation, whereas Dr. Kantor has found that in something like 25 per cent of all constipated people there are signs of redundancy.

While the cause is usually considered a congenital one, it seems to me there is a certain amount of evidence of its being acquired in some patients by overloading and stretching of the transverse colon and the sigmoid in chronic constipation and as a result of the abuse of cathartics.

The redundant colon is one that is too long. This is not a matter so much of absolute length, because Dr. Bryant has shown that the variation in the length of the colon in adults is all the way from 3 ft., 4 in. up to 10 ft., 10 in., in his series of 160 cases, but it is a matter of being too long for that individual abdomen so that the colon falls into loops and kinks, and so on.

I agree with Dr. Kantor that fully two-thirds of the redundant loops are on the left side of the colon; either the sigmoid or the splenic flexure or the descending colon.

With regard to frequency, in looking up the cases which we have noted in a series of 2000 consecutive gastrointestinal examinations,

I found only 26 that we would call really severe, which makes a percentage of only one and one-third; but we found something like 55 or 56 that might be called mild or moderate degree cases, so that makes 4 per cent in our total number of cases, as against Dr. Kantor's 8 or 9 per cent. However, I think this percentage might readily be increased if we had gone over the series more carefully and some of the milder or borderline cases were included.

In taking the severe group of our own cases, we found the sex incidence reversed from Dr. Kantor's; that is, we found 40 per cent of men and 60 per cent of women. Perhaps if we had had more cases, that might have been the other way.

We found the same relation to ptosis, somewhat to our surprise; that is, that two-thirds of the cases were in the sthenic, stocky people, and that only one-third were in the ptotic, asthentic type. Some of the persons who were afflicted with this trouble were most vigorous individuals; one was an admiral in our navy and one was a professional athlete. It is by no means confined to weak people.

With regard to symptoms, it is practically impossible to diagnose without the roentgen-ray, and of course that is a very good reason for presenting the subject before this Society. We have a definite entity; it is fairly common. It is important to think of in abdominal diagnosis, in constipation, when general abdominal symptoms are present or when there are local, painful attacks. In the severe group we found, as Dr. Kantor did, that about three-fourths of them had constipation and that local pain and distress occurred in something like 60 per cent of our cases.

We found a somewhat different distribution of the pain in looking over the severer cases: that while the lesion was usually on the left side, as I have said, the pain was referred to the right side in about one-half of the cases; that is, there was a throw-back from the left side into the cecum in localizing the pain, and that only in about one-eighth was the pain left-sided, and the rest were median. We had these severer colics, painful abdominal attacks, in nearly one-half the severer grade of cases.

We had one or two patients who had had an operation for appendicitis. We had one or two who were worrying about cancer, and we had others in whom diverticulitis and gall-bladder trouble had been considered, and several had had intermittent tumors which were obviously fecal tumors which came and went as the colon was unloaded.

It is not always easy, it seems to me, to draw the line between the long colon and redundancies. It is not easy to measure the length of the intestinal canal by a roentgenogram. My own impression is that there are a good many mild cases and a good many moderate ones and a certain number of severer ones.

With regard to the roentgen findings, I did not find a single case in our series in which the diagnosis had been made before the roentgen examination, and the loops were all varieties, about 60 per cent of them on the left side and about 30 per cent involving the whole colon and only 10 per cent on the right side, and the bowel was inclined to kink easily, like the inner tube of an automobile when it is partly inflated. We found by enema that it might take perhaps three or four quarts or more to fill the bowel, not because it was a big, dilated bowel, but simply because it was much longer and more capacious than the normal colon.

We got many strange pictures. We found gas-filled loops which would tip the stomach upside down and would drag on the pylorus and duodenum and deform it. In one case the transverse colon had slipped up above the liver and was seen as the gas-filled colon between the liver and the diaphragm, and we found long transverse loops of the sigmoid which, as Dr. Kantor has shown, sometimes would be transverse and sometimes vertical.

With regard to treatment, I have nothing to add, and in closing I think we are very much indebted to Dr. Kantor for emphasizing this condition which is fairly common, which is really important, which is discoverable by the roentgen-ray alone, and which up to this time has been somewhat neglected.

Dr. B. C. Darling, New York City. I would like to ask a question. We hear about contents in the colon being sidetracked and remaining for days, and therefore being a menace and necessitating what is known as colonic irrigations. I would like to know whether this side-tracking is a real thing? I don't see it. It seems to me that the contents mix, if they are retained from the cecum on out, and I have been skeptical of this theory. I would like to hear what Dr. Kantor has to say about it.

Dr. A. E. Colcher, Philadelphia. I would like to ask Dr. Kantor whether he pays any particular attention to the haustrations in the colon and particularly where he finds that there has been a delay of movement in the colon? For instance, whether it is the spastic type or whether it is the atonic type, and how he differentiates them; whether he differentiates them by means of noting the haustrations in the colon?

I have been doing work of this sort for the last three years and we are not quite through

with it. The reason why we want to know whether they are the spastic or the atonic variety is because we wish to treat them accordingly and either give them magnesium salts or calcium salts, as indicated.

Dr. A. H. Pirie, Montreal. In connection with all our abdominal cases, we ought to remember that constipation is the root of all evil; and secondly, that neither the patient nor his physician knows when he is constipated. A patient who has an action every day, or even twice a day, may still be intensely constipated.

Dr. E. D. McCarty, Tacoma, Wash. Has Dr. Kantor observed any ileal, duodenal and gastric stasis with his colonic stasis, as Dr. Jordan of England has observed?

Dr. L. T. LeWald, New York City. I have not encountered the redundancy in a sthenic individual. I shall go over the serious cases very carefully to see just how the percentage works out, but I would say roughly that in my experience it was in the asthenic type that I had seen the greatest number of redundancies. Secondly, I am for operation in cases that do not yield readily to medical means, and I have become more convinced of this in the last ten years. I have seen unfortunate results where this has not been done, and only favorable results where this has been resorted to in proper cases.

I have a case in a child ten years of age—and in children particularly I think we ought to watch this condition, and if it is so serious that it requires operative intervention, to have it done. In casting about for some less dangerous procedure than resection, we suggested plication of the colon. Plication was done in this case, and the result a year later was very much improved bowel movements; the lengthening was largely overcome by the plication.

There is one other type of operation, and that is complete resection of the entire redundant portion, which in another of our cases was enormous. In cases in which the symptoms are so persistent that they do not yield to medical means, I believe that one should not hesitate too long in advising resection, though I don't believe resection should be done in every case.

Dr. Kantor, closing. I am very much obliged to Dr. White for the compliment of reviewing his own material. I feel much gratified that his experience is as nearly comparable as one could ask.

Dr. Darling asked about the need for colonic irrigations, and, if I understood him, about this idea of sidetracking. It seems to me anything like colonic irrigation is wrong, because it is only transient. You can't cure the patient of his constipation that way.

Dr. Colcher asked about haustrations. We do look at those with great interest because the haustrations are the only way of identifying the spasticity. We regard spasticity as universal, almost, varying in degree and intermittent in its manifestation. The treatment would not be modified very much by differentiating. I think spasticity requires more treatment.

Dr. Pirie brought out the point about the patient not knowing when he is constipated, that is, the individual takes constipation so for granted in these individual cases, that he comes to the physician and forgets to mention the matter of constipation.

As to Dr. McCarty's question about ileal stasis and gastric stasis, I haven't been able to see much of that. I asked Dr. Case about that and I am not clear about it as yet; I can't answer it.

As to Dr. LeWald's point about thinking the condition is more common in asthenics, all I have to say is that I thought so before I had reviewed the figures. On review of the figures, I feel that he will find that it is more common in sthenics.

Finally, as far as operation is concerned, plication may do some good if done very carefully by men who are skillful with their fingers and are good thinkers, but resection has been a very costly price to pay for these things and is not to be recommended as routine procedure.

SOME ANOMALIES OF THE KIDNEY*

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IT not infrequently happens that disease of the kidney is either caused or complicated by the presence of some anomaly in the position or form of one or both kidneys, and in cases in which a nephrectomy is comtemplated it is of prime importance to determine whether or not there are two completely separated kidneys. For aid in the determination of the presence of these anomalies, as in the diagnosis of various pathologic conditions of the kidneys, the urologist turns to the roentgenologist. The need on the part of the roentgenologist for a better understanding of the various types and anomalies of the kidneys has been emphasized by Mertz in a paper presented last year before the Urological Society at Rochester, in which he reported a series of 30 cases with double kidney pelves, 23 per cent of which were not correctly diagnosed from the roentgenological findings. He therefore concluded that "if such an error was not to be repeated indefinitely a better knowledge of the types of the pelves of the double kidneys was necessary."[1] I feel that this statement should be extended to apply to all types of kidney anomalies.

Anomalies of the kidney may be roughly classified as (*a*) anomalies of number, which include congenital solitary kidneys, congenital atrophy, fused kidney and duplex kidneys; (*b*) anomalies of position which include ectopic and misplaced kidneys and torsion; and (*c*) anomalies of form, which include polycystic kidneys. Among these groups the first is of especially vital importance to the genito-urinary surgeon.

Congenital solitary kidney is of rare occurrence, the statistics of Motzfeld showing that it occurs about once in every 1000 individuals. This term, congenital solitary kidney, refers only to the congenital absence of one kidney and should not be applied to a single kidney which remains after an opposite nephrectomy nor to ectopic or fused kidneys. When only one very large kidney is visible on the roentgenogram the possibility that it may be a congenital solitary kidney should be borne in mind, although Eisendrath states "that the size alone is not a criterion unless it is very large, because the kidney in a certain proportion of cases is approximately normal in size."[1] Roentgenograms taken with catheters *in situ* may show either a solitary ureter or that the catheter has passed only a short distance in one ureter and to the pelvis of the kidney in the other. Often the passage of the catheter will reveal the crossing of the ureter of the solitary kidney to the oposite side of the bladder. In such a case pyelograms will show a normal kidney and ureter on one side and only a rudimentary ureter on the other. These cases are usually sent to the roentgenologist because of some pathological condition other than the anomaly but we believe that by careful study a fair percentage may be correctly diagnosed by roentgen examination before operation.

Congenital atrophy or hypoplasia of the kidney is a result of arrested development, which may have occurred at any stage in the development of the fetus, so that this type of anomalous kidney may show any variation in size from microscopic to nearly normal. Sometimes small, so-called "rice-grained" stones are found in these congenital atrophied kidneys.

The diagnosis of a congenital atrophied kidney, especially in the more marked cases, can usually be made from the appearance of the kidney on the roentgen film as compared with the appearance of the kidney on the opposite side since usually the atrophic kidney is somewhat irregular in shape and smaller than the opposite kidney. A pyelogram makes it possible to determine whether or not a corresponding anomaly of the pelvis is also present. From the surgical standpoint, however, the extent of the anomaly is not of great importance as the advisability of an operative pro-

[1] Pelves of double kidney. *J. Urology*, 1924, xi, 259–291.

[1] *Ann. Surg.*, lxxix, 206.

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

cedure depends upon the results of the functional test, the important point being the discovery that the anomaly exists.

Fused Kidneys. Fused kidneys may assume a number of different forms, the most common of which is the "horseshoe" kidney, so named from the crescent shape, produced by the fusion of the lower poles of the two kidneys. The possibility of the presence of a horseshoe kidney may first be suggested by the kidney outline and its location on the plain kidney films. A horseshoe kidney casts a continuous shadow across the spine, from one lower pole to the other and the two kidneys appear to assume a vertical position. If a study of the pyelogram discloses torsion in one of the pelves with the calyces anterior and extending downward, a horseshoe kidney should be suspected.

FIG. 1.

FIG 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

PLATE 1. Figure 1 shows a normal kidney pelvis and Figure 2, a normal kidney pelvis, with a long cephalic calyx Figures 3, 4, 5 and 6 show incomplete duplication of the kidney pelvis.

The discovery of a horseshoe kidney in the presence of some other pathological condition of the kidney such as a tuberculous infection is very important, as the presence of a horseshoe kidney makes nephrectomy impossible and its discovery may often spare the patient an exploratory operation.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

PLATE 2. Figures 1, 4, and 8 represent duplex kidney pelves. Figures 2 and 6 show the cephalic calyx filled and Figures 3 and 7, the caudal calyx filled. (Figures 2 and 3 represent the same case.) Figure 5 is a pyelogram of the opposite kidney of the case shown in Figure 4 showing the characteristic long cephalic calyx.

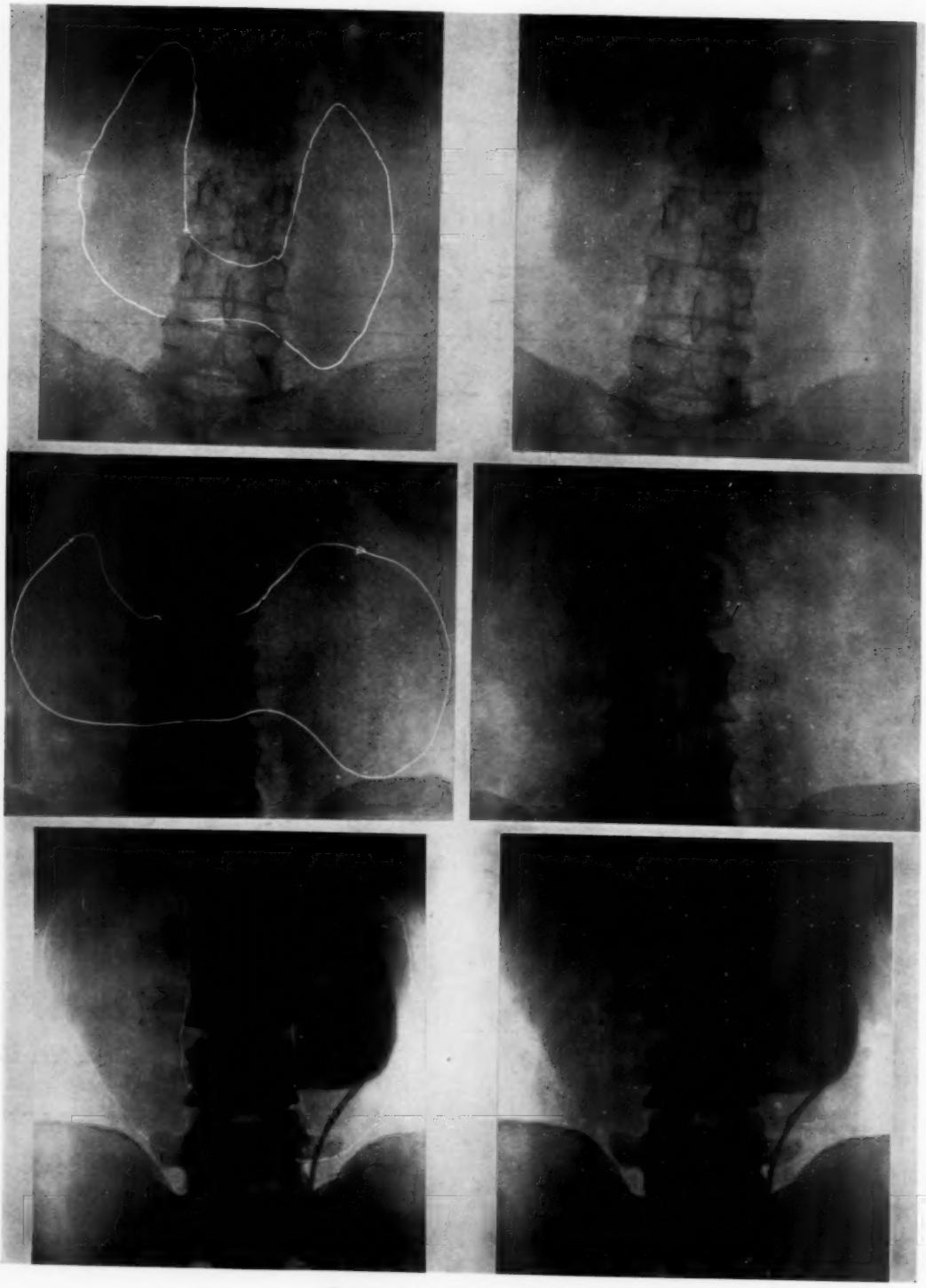

PLATE 3. Horseshoe kidneys.

Other types of fusion of the two kidneys may be found. The continuous mass of kidney tissue together with the various shapes and positions of the pelves of such kidneys as determined by pyelography will establish the diagnosis.

the normal pelvis by the division of the ureteral bud into two major calyces, the superior or upper calyx and the inferior or lower calyx. The extension of this division results in the bifid pelvis or complete duplication of the pelvis and the ureter.

FIG. 1.

FIG. 2.

FIG. 3.

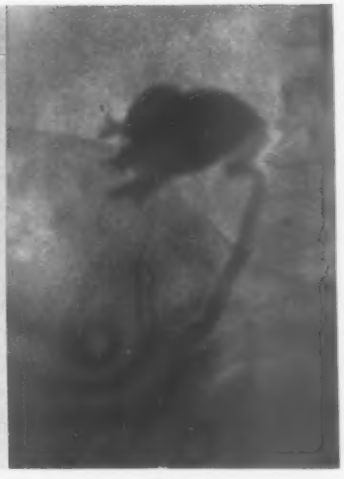

FIG. 4.

PLATE 4. Anomalies of position. Figures 1 and 3 show normal, low lying kidneys, Figure 2, an ectopic kidney and Figure 4, a pelvic kidney with a kinked ureter.

The Duplex Kidney. From the standpoint of differential diagnosis, the duplex kidney is perhaps the most important anomaly. The extent of this anomaly varies from what may appear as little more than a long cephalic calyx to complete duplication of the pelvis and ureters. In interpreting this anomaly it is necessary to bear in mind the embryonic formation of

Occasionally three or four divisions of the ureteral bud may result in three or more major calyces. In our opinion, however, this is extremely rare. The minor calyces are rather extensions from the major calyces, the so-called middle major calyx, according to Papin, being only a minor calyx extending from the junction of the superior and inferior calyces and

usually belonging to the inferior major calyx.

In our experience the cephalic calyx of the duplex kidney is usually the one outlined on the pyelogram if only one is injected. This calyx presents a rather characteristic dumb-bell shape extending almost directly upward and slightly outward. In the presence of this type of pelvis the possibility of a duplex kidney should be suspected and further search should be made for the caudal calyx. If the caudal calyx alone is injected, the appearance of a normal pelvis with an absent cephalic calyx is given and this again should lead us to suspect a duplex kidney. It should be borne in mind, however, that a tumor of the kidney may obliterate the caudal or cephalic calyx thereby giving a picture simulating a single pelvis of a duplex kidney. Such a tumor is usually a papilloma which springs from the pelvis and either occupies or by pressure occludes one of the major calyces. Hematuria having its source in the suspected kidney, especially if only one ureteral outlet is

FIG. 1.

FIG. 2.

FIG. 3.

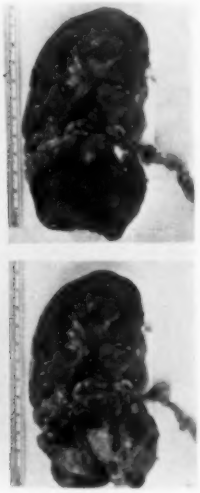

FIG. 4.

PLATE 5. Figure 1 shows a congenital anomaly of the kidney pelvis with 5 major calyces and Figure 2 a congenital polycystic kidney. Figure 3 shows the obliteration of the caudal calyx from tumor, simulating a duplex kidney, and Figure 4 shows the papilloma specimen from Figure 3.

found in the bladder, should suggest the possibility of a tumor.

The Pelvic Kidney. A true pelvic kidney is a low lying kidney which derives its blood supply from the iliac artery, so that it has a very short renal artery and pedicle; a low lying kidney, the position of which is due to arrested ascent or traumatic displacement, derives its blood supply from the aorta. The pelvis of a kidney which has been displaced by trauma is usually normal in outline but lies in a low position and has a kinked ureter. A low lying kidney, the position of which is the result of arrested development, may have an undeveloped pelvis and be confused with a true ectopic kidney. Pyelograms of kidneys which are anomalous in position in most cases make it possible to determine the type of anomaly.

Renal torsion may be either acquired or congenital. The usual normal position of the kidney is between the level of the 12th dorsal vertebra above and the 3rd lumbar below, the long axis being directed downward and laterally, the transverse axis backward and laterally. In the process of development the embryonic nephrogenic tissue with the ureteral buds ascends from the bony pelvis until it reaches the normal position described above. When the embryo is about 10 mm. in length, if the normal position is reached, the kidney rotates, the hilum and pelvis which were in an anterior posterior position assuming a position with the pelvis toward the vertebral column. It is obvious that many deviations may occur in the progress of this morphological cycle. Thus, the kidney pelvis may assume a position directly anterior to the calyces or the normal relations between the calyces and the pelvis may be completely reversed so that the pelvis will lie to the outer side and the calyces project directly inward toward the spine. We can readily see that when the ascent is interrrupted rotation would at the same time cease, leaving the kidney pelvis in its original anterior position where it is so often seen in cases of renal torsion. In the case of a fused kidney, one pole may follow a fairly normal ascent so that the corresponding pelvis will attain an approximately normal position. When one considers the possible variations in the migration of the nephrogenic elements, it is easy to see how the rate of development of the segments of a fused kidney may vary from slight torsion to complete reversal of the normal relation of the calyx and pelvis. It follows, therefore, that the appearance on the films of a pelvis which appears to be in a position of torsion should suggest the possibility of an ectopic or a fused kidney. In these cases the kidney has approximately the outline of the kidney as seen on plain kidney films, this apparently normal outline together with the relative position of the kidney often making possible an intelligent preoperative interpretation of the type of anomaly which is present.

Polycystic Kidney. This type of anomaly is rare. The records of the Boston City Hospital during a period of ten years, disclosed only 10 cases among 2429 autopsies. The polycystic kidney, as its name implies, is characterized by many cystic areas, some large and some microscopic in size, located for the most part at the renal parenchyma. The outline of the polycystic kidney is usually irregular, the irregularities corresponding to the cystic areas; pyelography reveals a kidney pelvis markedly deformed by the encroachment of these cysts upon the calyces. Hydronephrosis may also be present, caused by obstruction from the cysts. Occasionally these cysts may rupture and the resultant filling of the cavity with the injected medium may suggest pyonephrosis, but a careful study of the irregular outline of the kidney will usually reveal the true nature of the pathology. The multiple circumscribed areas revealed by the pyelogram may nearly always be regarded as pathognomonic of a polycystic kidney.

In this brief discussion I have attempted to include only those anomalies which according to our experience are most commonly seen; a careful consideration of these will materially increase our percentage of correct interpretations of pathological conditions of the kidney.

DISCUSSION

Dr. L. B. Morrison, Boston. Dr. Nichols' paper emphasizes the fact that we are con-

stantly encountering these various anomalies, and although in the aggregate the number is small, yet every one of us, I think, is puzzled at times by such anomalies.

Dr. Nichols has covered the ground so thoroughly that it leaves very little for discussion. The thing that I noticed particularly is that in many of these anomalies the function and the character of the pelvis is undoubtedly normal to that kidney, but in certain types, when the ureter came off in a certain position in the pelvis hydronephrosis is produced. I think that is a thing to be noted, that the position of the ureter and its pelvis in all types of kidneys, whether the normal or abnormal, may indicate future trouble for the individual. Very few horseshoe kidneys give trouble. It is only when there is displacement by afferent vessels that trouble ensues, because the vessels are very commonly varied tremendously in these horseshoe types. We may find them, as Dr. Nichols states, anywhere in the abdomen from the twelfth dorsal down to the pelvis. They may be fused below or on the top, more commonly below. The fused portion may be behind the aorta or in front, and the ureter may come into the bladder or even down into the prostatic ureter.

THE NATURE AND DIFFERENTIATION OF PLEURAL ANNULAR SHADOWS*

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ON a number of occasions during the past five years the assumption that all annular shadows appearing in roentgenograms of the pulmonary fields represent cavities within the lungs has been questioned, and other anatomical alterations have been invoked to explain the presence of some of them. While certain clinical and roentgenological observations lent convincing support to the hypothesis that many of these densities are to be interpreted as pleural changes, it was not until the past year that actual proof was forthcoming from autopsy studies. Not only has the pseudo-cavitary ring shadow been demonstrated to be a reality, but it appears also that such a shadow may sometimes occur in conditions other than tuberculosis. Most often, in the cases reported, the lesion has been found to be pleuritic.

Early in the year, Hebert[7] reported a unique observation of a case of pulmonary tuberculosis in which a large annular shadow developed within a month simultaneously with the clinical appearance of a pleurisy at the same site. Later, following the induction of artificial pneumothorax, he was able to demonstrate that this part of the visceral and costal pleura was adherent, and finally that the shadow became much reduced in size as the adhesions separated, its remains still being visible on the surface of the collapsed lung. He concludes that the lesion was pleuritic, and makes the generalization that large annular shadows are probably due to pleural changes and have no important clinical significance if they appear quickly, change in size, show no increased translucency in the center, or finally disappear; smaller shadows of this type, even though they appear in a comparatively healthy area of lung, are often due to tuberculous cavities.

Rusk and Randolph[8] record 2 cases diagnosed as tuberculous in which the roentgenograms showed annular shadows interpreted as cavities. At autopsy the lesion in one case was found to be that of pneumonoconiosis, and in the other, metastatic carcinoma with fibrous pleural adhesions over the left apex in the region of the annular shadow. In neither case was a cavity found.

De Jong and Pestel[9] publish a detailed report of a case of tuberculosis showing a large annular shadow, with postmortem findings. At first there were no signs of cavity over the site of the shadow, but later extensive excavation was recognized clinically. At autopsy a large cavity was found together with widespread and dense pleural thickening. The authors reason

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

that the annular shadow was originally caused by a pachypleuritis and that, later, as the clinical course became progressively unfavorable, a caseation of the lung developed within the zone limited by the annular shadow, finally undergoing cavitation.

Casellas[10] publishes reproductions of the roentgenograms of 4 cases of pulmonary tuberculosis in which the autopsy showed no cavities in regions where annular shadows appeared. He accepts the explanation, on his postmortem findings, that pleural annular shadows are most often due to simple subacute or chronic localized pleurisies.

Recently Casellas has sent me from El Paso a roentgenogram of an unusual and very interesting case with the autopsy report. The roentgenogram was made after the lungs were removed from the chest and inflated, and shows a definite, fairly large annular shadow. The case was supposed clinically to be one of pulmonary tuberculosis, but at autopsy no tuberculosis was found. Instead, bronchopneumonia was demonstrated, and at the site of the annular shadow there was thickened pleura in annular formation surrounding an area of umbilication of the lung surface. Adhesions were present in this region and beneath the ring of thickened pleura a soft hemorrhagic infarct was discovered. This is the only case of the kind that I know of, and it tends to prove that a variety of lesions of the lung accompanied by pleuritic changes may at times cast annular shadows.

In discussing the paper read before this society by Brown in 1922, Manges mentioned having seen at autopsy, during the influenza epidemic of 1918, instances of localized pleuritis which might well have produced annular shadows. Assmann (cited by Piguet and Giraud[11]) has also observed these shadows in certain febrile conditions, particularly in the pulmonary complications of typhoid fever, where no cavitation existed. Most studies, however, have been confined to the occurrence of the phenomenon in pulmonary tuberculosis, since annular shadows of one kind or another are found most commonly in this disease and their proper interpretation is of great importance in diagnosis and treatment.

The nature of the pleural lesions, accompanying pulmonary tuberculosis, which may give rise to circular densities on the roentgenogram has been a matter of some debate. Sampson, Heise and Brown,[1] Evans,[2] and Dahlstedt[3] offer the explanation that they are circumscribed pneumothoraces due to lung rupture, while Honeij believes that they are to be explained on the basis of pleural inflammation. In previous publications[5] I have stated my views which are that the shadows are produced most often by simple subacute or chronic localized pleurisies which may or may not be associated with umbilication or puckering of the subjacent lung tissue and consequent localized separation of the pleural layers; the resulting interstice may contain freely movable fluid. While lung rupture may on rare occasions result in a pocketed pneumothorax of circular or spheroidal shape, it is not probable that this mechanism is by any means the usual explanation of the densities in question which are of fairly frequent occurrence. The reasons for this have been explained in previous papers. The pleurisy hypothesis is best adaptable to the clinical and roentgenographic findings, and Casellas, and de Jong and Pestel, from autopsy studies, believe that they have confirmed this as the correct assumption. Casellas especially has not only found the circumscribed pleuritic lesions at autopsy, but on inflating the isolated lung he has also been able to demonstrate a well-pronounced umbilication or cupping at the site of the lesion, this portion being the last to attain full expansion. He has been unable to confirm the theory of ruptured lung as the cause of pneumothoraces simulating cavities. In fibroid phthisis he has found annular shadows near the hilum caused by circular deposits of fibrous tissue. Assmann considers the possibility of circular shadows being produced by a peribronchial lymphatic engorgement or by an inflammation of the lymphatic vessels surrounding the arteries and bronchi as a compact network. However, it is not likely that such shadows would be of great size.

It is an artificial distinction to confine any discussion on this subject to shadows which are strictly annular, for many, undoubtedly of the same nature, take on other geometrical shapes, and still others belonging to the category of pleural phenomena may be amorphous. With this in mind it is difficult to estimate accurately the frequency of incidence. But, taking those shadows alone which are really annular or very nearly so and which simulate true cavity shadows, it seems safe to say that they constitute a group sufficiently large to be of considerable importance in differential diagnosis. Their occurrence depends to a certain extent on the type of intrapulmonary disease and its condition of progression or retrogression. In chronic, progressively or intermittently active tuberculosis they may appear in more than 10 per cent of the cases. True cavity shadows are, of course, relatively much more frequent and the tendency sometimes to call most doubtful lesions of this kind pleuritic is to be decried, because under such indecisive circumstances the laws of chance alone favor cavitation. Nevertheless, the importance of accurate differentiation should be obvious: true cavity is of very serious significance in treatment and prognosis while annular pleural lesions are usually mere coincidences, secondary to and more or less dependent on the intrapulmonary lesions. One proven feature of pleural rings is that they usually develop and increase in size as accompaniments of active pulmonary disease, and diminish or disappear as this becomes quiescent or healed.

The evolution of true cavities and of pleural lesions is of most value in distinguishing the two conditions. Tuberculous cavitation is dependent on preceding caseation. At its inception, therefore, such cavitation appears most often as irregular, variable and multiple rarefactions of a preceding heavy density; the appearance has been described by the French as that of a bread crumb or honeycomb; at times it may be likened to a moth-eaten fabric or a melting lump of sugar. In other words the rarefactions are ragged and poorly defined. Later, if the process continues, the rarefactions merge. They may remain ragged if the disease is rapidly progressive, in which case they may never become definitely spheroidal. At times, as Casellas points out, the cavity assumes a pyramidal shape corresponding roughly with the arrangement of pulmonary stroma. In these instances the cavity is almost always walled about by dense caseous material which is seen to melt away as the rarefaction widens. If and when the lesion tends to become localized and encapsulated, the cavity often assumes a roundish or spheroidal shape. Then it becomes better defined and its inner border may be smooth and sharply defined. It may stand out as a conspicuous circle while the surrounding parenchyma shows relatively slight evidence of infiltration, but usually the adjacent field is mottled or clouded. The cavity may be sharply limited on one side by a band of interlobar thickening. When it is chronic and extensive, fibrous trabeculae may be seen traversing it. Ragged rarefaction of caseous densities may progress rapidly, but localization and encapsulation usually require many months; the two processes of destruction and repair may proceed successively or simultaneously.

Pleural annular shadows develop, without any demonstrable rarefaction of intrapulmonary densities, usually in the upper and posterior parts of the chest or in the planes of the interlobar fissures. The inner border is practically always sharply defined while the outer one gradually shades off, sometimes extending as a diffuse cloud over wide areas of the field or as a pleural cap enveloping the apex. Through the ring unbroken pulmonary markings can often be distinctly visualized. The shadow increases in size by a uniform widening of its internal circumference, practically never by a coalescence of smaller shadows. A feature of distinction is the frequent rapidity of its extension without a proportionate change in the pulmonary infiltration. The pleural shadow may spread itself over a wide area of the field in several weeks or months while the relatively small pulmonary densities show little change in distribution, although their collateral haziness may become more intense.

True cavities may become greatly contracted or obliterated by the shrinkage of

enveloping fibrous tissue, a process which requires from two to three years or longer of slow healing. I have never seen an area of rarefaction more than 4 or 5 cm. in diameter in the roentgenogram disappear by this mechanism. Piguet and Giraud[11] believe in a second important mechanism leading to the healing of cavities, namely, compression exerted on the walls of the cavity by the action of compensatory emphysema developing in the vicinity. They argue that large cavities may heal in the space of several months by this means. Their observations, however, are not convincing because in some of the reproductions accompanying their article there is not even a vestige of a demonstrable scar to mark the site of a so-called healed cavity. The same criticism applies to a certain extent also to the conclusions of Brown and Burnham[6] who believe that rapid obliteration of cavities is not uncommon. On the other hand, it is a frequent occurrence to find pleural annular shadows shrinking rapidly and finally fading from the picture; such a change may be effected in a few weeks or months. At the same time there may be no change in the underlying pulmonary densities, save the usual orderly slow healing. In the end it may be impossible to demonstrate a trace of the pleuritic process. In contrast, the site of a healed cavity is always marked, I believe, by the density of fibrous tissue; adjacent compensatory emphysema may be the result of healing and retraction but is not likely to be the cause of it.

The demonstration of a bronchial communication with the annular shadow is presumptive evidence of cavity.

By obtaining lateral or oblique views of the chest, or by demonstrating a shifting fluid level within the annular shadow, the presence of an enclosed space of three dimensions may be proven. Brown and Burnham take this as conclusive evidence of cavitation; Dahlstedt considers it as proof of the existence of an encysted pneumothorax due to lung rupture. Both may be partly right. This finding is merely of a space. If the space can be shown to lie within the lung, it is a true cavity; if it is confined to the pleural cavity, it may be caused by a simple puckering or umbilication of the lung subjacent to the annular shadow and may have no relation to lung rupture.

If the fluid level within the shadow varies greatly from day to day, or if it disappears with postural drainage, the evidence favors true cavity.

It has been suggested that the injection of some opaque substance such as lipiodol or the insufflation of bismuth might aid in distinguishing these lesions, but the applicability of such methods in tuberculosis is limited.

Occasionally annular shadows appear as a serofibrinous pleurisy becomes absorbed, and rapidly vanish as organization progresses; in such cases the pleuritic nature of the density is easily identified.

The withdrawal of serous fluid from the area enclosed by the annular shadow speaks for a pleuritic process. In one case in which I[5] reported this finding, the patient died following pneumothorax treatment and a last resort thoracoplasty. At autopsy a cavity was found, apparently disproving the original assumption although a special study of the pleura was not made.

After the induction of artificial pneumothorax in cases of this kind, the rarefied areas within the lung are often more clearly defined. In others such areas are not shown, but adhesions may be demonstrable at the site of the pleural lesion; the case of Hebert's is a striking example of this.

Close cooperation between the roentgenologist and the clinician is essential if the element of error is to be reduced to a minimum. I have discussed the clinical side of this question in previous communications, and shall refer here only to a few points which are especially important when the correct interpretation of annular shadows is difficult. Clinically, certain cavities give physical signs which are unmistakable; others give equivocal signs; and a small percentage are "silent." Furthermore, if a patient has expectoration containing tubercle bacilli, an ulcerative focus almost always exists in the lungs; the more copious the expectoration, the larger the cavity is likely to be. Conversely, a demonstrable cavity of any considerable size almost always gives rise to sputum

containing tubercle bacilli. Now, if the roentgenogram shows a single doubtful annular shadow without any other rarefaction, and the patient has sputum with tubercle bacilli, that shadow probably represents true cavitation, which may or may not give physical signs. If, on the contrary, a sizable annular shadow appears and the patient has no tubercle bacilli in his sputum or no sputum, the lesion is probably pleuritic, especially if no physical signs of cavity can be elicited at its site.

I mention these facts principally to suggest the importance of correlating all findings in a given case. There are many doubtful annular shadows, the interpretation of which the roentgenologist must state on the basis of probability. In these instances, at intervals of weeks or months, repeated observations may be necessary to determine the true nature of the process, but usually this ultimately may be identified.

Finally, I wish to second the recently expressed opinion of Sergent[12] that no one has the absolute right, even with the aid of the roentgen ray, to affirm the existence, much less the extreme frequency, of silent and visible cavities unless he can prove this extreme frequency at autopsy. Sergent argues further that one cannot deny that false cavitary shadows may be just as frequent.

CONCLUSIONS

1. Pleural annular shadows are realities which must be distinguished from intrapulmonary cavity shadows.

2. The lesion casting such shadows appears most often to be a subacute or chronic localized pleurisy which often undergoes rapid changes in size. This may be accompanied by a puckering, dimpling or umbilication of the subjacent pulmonary tissue, and the resulting pleural interstice may contain a small amount of fluid.

3. In most instances pleural annular shadows can be identified by the methods of observation suggested.

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DISCUSSION

Dr. William A. Evans, Detroit, Mich. Dr. Amberson's presentation I think makes available for our records a convincing answer to the last article in our Journal on this subject by Brown King. Dr. Amberson has brought out what we lacked in our original contribution and in the following contributions on the subject. I refer to the pathological and postmortem evidence of a pleural basis for many of these annular shadows.

Our original work was done in 1918, and at that time we did use the term "localized pneumothorax," but we did not intend to convey the idea that that was the real basis for the annular shadow. We did have this in view, that we had primarily a superficial pulmonary lesion, and that following this there was involvement of the pleura with resulting pleuritis, and that the area of lessened density was formed by a breaking through of the lesion into the central area of the thickened pleura, with the resulting drainage of the effusion and with consequent pneumatization of that portion of the pleura. Of course, in the early presentation we did not cover the whole field.

Our original work included the demonstration of 7 cases in which there were annular shadows occurring in lungs without any other evidence of pulmonary tuberculosis, and we had the further evidence in our mind that these annular shadows were not cavities, because they changed their size and shape so rapidly; and further we had another case in which we showed the inability of the lung to collapse in a pneumothorax as a result of this pleural thickening. Of course, we have since learned that other lesions will produce the shadows of circular pleural thickening and not necessarily represent a true pleural involvement from an underlying pulmonary lesion.

I cannot take issue with Dr. Amberson because he supports, I think, very clearly our contention made some six years ago.

Dr. Willis F. Manges, Philadelphia. I don't know why I am called upon formally to discuss this paper. I have never written anything on the subject, but did, as the essayist remarked, discuss Dr. Brown's paper at Los Angeles, at which time I seemed to be the only one who had the courage to disagree with Dr. Brown and Dr. Burnham. They, as you remember, attempted to prove that all of these so-called annular shadows were really pulmonary cavities. My reason at that time for objecting to his stand was that in one particular case it seemed so perfectly clear from stereoscopic films that the annular shadows were distributed along the plane of the interlobar fissure between the upper and lower lobes; on the left sides, from apex almost to base there was a series of these annular shadows and you could distinctly see that in the upper part of the chest they were posterior and gradually became more anterior to the lower portion of the chest. There was a series of rings that to my mind were clearly in the interlobar fissure; that is, involving the pleura between the lobes, and not cavities so distributed in the lungs.

The same patient showed very positive evidence of cavities in both apices as well.

I think that this communication of Dr. Amberson's is particularly valuable because it finally puts at rest any question as to whether this annular pleural shadow is an entity or not.

Dr. David R. Bowen, Philadelphia. There are two allied conditions which seem to me to support this theory very pointedly. One is the encapsulated empyema which has either been opened or has ruptured into the bronchus; and the other the lung abscess, showing a cavity in the same way; and the rapidity with which these things heal and absolutely disappear as compared with the true tuberculous cavity.

I have several slides now of encapsulated empyemas showing cavity and fluid level, and so forth, in which in approximately a year's time (I happen to remember that one of them is a year and a day) there is absolutely no sign of the lesion, and when a well defined lesion like that will so completely disappear, it seems to me it lends a great deal of color to this theory of the pleural annular shadow.

Dr. Amberson, closing. I think there is nothing further to say, except in reply to the statement made by Dr. Brown a year or so ago that artificial pneumothoraces never attain annular formation, that I have one case which I did not refer to in which there was a pneumothorax following administration of gas, which on the roentgenogram had an appearance precisely like these shadows and which later shrank down and disappeared, making it impossible for us to go ahead with the pneumothorax.

SYPHILIS OF THE STOMACH WITH A STUDY OF TEN PROBABLE CASES*

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CHIARI, writing of gastric syphilis in Virchow's Festschrift in 1891, says, "Yet there are a few organs respecting which our knowledge of their syphilitic affections is not at all complete. To this class of organs belongs the stomach."

Except for some additions to our knowledge of the clinical signs and the assistance of modern diagnostic methods we know but little more today and little has been added to the pathological picture.

The condition is essentially a late tertiary lesion, probably the result of ulceration due to syphilitic endarteritis or degeneration of gummata, with breaking down and cicatricial contraction. There is secondary sclerosis with deformity. Syphilitic disturbances of the stomach occurring earlier in the course of the infection are not recognized as such and are diagnosed as functional or coincident gastric disease. They are transitory and disappear under treatment. As surgery is not indicated at that stage and since they are seen only rarely at autopsy, when they may be recognized as syphilitic, little is known of their early pathology.

Andral in 1834 first called attention to this condition and described 2 cases.

Eusterman divides the history of its study into three periods: (1) From 1891 beginning with Chiari's studies, to 1905, in which period the study depended chiefly upon post mortem material; (2) 1905 to 1910, during which clinical study and therapeutic test furnished all the diagnostic evidence; and (3) 1910 to the present time when earlier methods of study were aided by serology and roentgenology. Only in the last period has the condition been well recognized and the literature greatly enriched by the contributions of such writers as Carmen, Eusterman, Einhorn, Downes, LeWald, Myers, Morgan, Smithies and others.

The frequency of its occurrence is only surmised. It is generally conceded to be rare but most writers believe that it is more common than has been thought. The opinion varies greatly from that of Castex and Mathis supported by Parody who affirm that all gastric ulcers are of syphilitic origin, to Symmers who found only one positive lesion in 4,480 autopsies. Eusterman found 1/3 of 1 per cent in 2,500 cases of operated benign ulcer. Brams and Meyer in 1923 find only 14 cases reported "with sufficiently complete anatomical reports to warrant a diagnosis." White found syphilis in 0.5 per cent of a series of private cases and in less than 2 per cent of hospital cases of ulcer. Fowler estimates that not more than 1 per cent of ulcers are syphilitic. Smithies found a positive Wassermann reaction in 0.33 per cent of a series of proven ulcers. Chiari's percentage was 1.2 per cent. Ewald believed that 10 per cent of gastric ulcers were of syphilitic origin. It appears to be more frequent in men than in women—Mills says twice as common. It occurs in early middle life, in the forties or earlier, averaging somewhat earlier than cancer. The time of the appearance of gastric symptoms after the initial lesion varies. Mills finds the average about 10 years. Eusterman from data in 16 cases finds an average of 11 years with extremes of 1 to 28 years.

The symptoms may be much like those of ulcer. The story tends to be shorter than ulcer, but longer than cancer. There is less tendency to periodicity than in ulcer. The symptoms are either constant from the beginning or become constant after a period of a few months of irregularity. Distress generally appears immediately after eating and continues until the stomach is emptied. It is not relieved by alkalies or food. Vomiting, spontaneous or induced, gives relief. Flatulence is common. Loss of weight is the rule and is often great but is not attended by the degree of cachexia or weakness seen with cancer. Pain is an almost constant symp-

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tom and is referred to the epigastrium, sometimes the left hypochondrium or radiating to the back. The pain varies in character; it is more often a severe distress or a dull overfilled feeling, sometimes cramplike, and generally continuing until the stomach is emptied. Vomiting immediately after food is a common and valuable sign and is often present from the onset. Hemorrhage is rare, although severe and fatal hemorrhage has been reported. The appetite is usually good but is often restrained from fear of the resulting distress. Constipation is noted in about 50 per cent. Alternating constipation and diarrhea is sometimes seen. The blood picture is normal or shows a mild degree of anemia.

Abdominal examination usually reveals no palpable tumor. No mass corresponding to the extent of the deformity seen by roentgen examination is found as in cancer. This is probably because of the absence of sharp demarcation of the lesion in the gastric wall and the contracted condition of the stomach.

The gastric analysis shows hypochlorhydria or achylia as a rule. This anacidity seems characteristic of the disease.

The diagnosis is based on evidence of a late syphilitic infection, an atypical history or history somewhat suggestive of ulcer, marked emaciation without corresponding cachexia, good appetite with distress immediately following food and relieved by vomiting but not relieved by food or alkalies, a roentgen picture suggestive of cancer, a positive Wassermann, continued progress or no improvement under accepted ulcer treatment, and cure or improvement under antisyphilitic treatment. It must be remembered, however, that "syphilitics often suffer from other organic lesions entirely independent of coexisting lues" (Einhorn); "the incidence of gastric ulcer is the same in luetics as in uninfected" (Niles); and "a gastric lesion in the presence of a positive Wassermann is not necessarily specific" (Eusterman). Fowler describes a case of benign gastric ulcer proven at operation in a syphilitic. A negative Wassermann does not exclude the possibility of gastric syphilis. Temporary improvement of a nonspecific lesion in a syphilitic may follow specific treatment from improvement of general condition or increased resistance.

Although it is often difficult to complete the chain of evidence in the absence of biopsy or necropsy it is probable that we may accept Eusterman's statement that "the evidence of specificity may be as logical as many other freely accepted facts of medicine" and in strongly presumptive cases consider the evidence sufficiently strong to warrant recourse to antispecific treatment and include such cases in this classification.

The roentgen findings are marked gastric deformity tending toward one of two types varying according to the location, extent and duration of the deforming lesion. Either a median deformity of the stomach with contraction, sometimes to a distinct hour-glass shape, or a deforming contraction of the pyloric end extending upward and involving the stomach wall to a variable extent, sometimes extreme, and forming a characteristic "water-bottle" shape. In the latter class pyloric obstruction is much less common than might be expected from the extent and location of the lesion. The pylorus, on the contrary, seems incompetent and the contents pass out of the stomach very freely. The duodenal cap, as a result, often appears large as though dilated. Weak, shallow or absent peristalsis is noted over the involved area. The extent of the infiltration is usually greater than the deformity seen on the roentgenogram would indicate but the absence of peristalsis or appearance of inflexibility and smoothness or absence of rugae in the stomach wall as seen on the roentgenoscopic screen suggests more nearly the extent of the involvement.

Some improvement in the roentgen picture may be expected after antisyphilitic treatment, the amount depending upon the original extent of the deformity and the amount of fibrous contraction present. In the extreme cases with marked hour-glass or water-bottle contraction the lumen of the stomach probably is never restored.

At operation or necropsy the stomach shows a marked deformity with contraction and diminution of size. A diffuse infiltration in the regions shown by roent-

gen examination is found, somewhat suggesting cancer but lacking the hardness or nodular feel of a malignant tumor. Often the two cannot be differentiated by the surgeon. Perigastric adhesions may be present. No evidences of metastases are found and the changes in the adjacent glands are not characteristic of malignancy. The degree of involvement, the duration and the severity of the gastric symptoms seem to be in direct relation.

FIG. 1. Case 1. Shows pyloric deformity.

The appearance of the gross section is unlike that of benign ulcer. The ulcerations are invariably multiple, irregular, shallow, sometimes linear, with a base clean or covered with a thin coat of fibrinous exudate containing some debris and a few leucocytes. The deformity is in part the result of the cicatrization of multiple ulcers. The submucosa feels distinctly thickened and dense.

Upon microscopical examination the appearance is unlike that of either cancer or benign ulcer. The mucosa usually shows atrophy. The submucosa is much hypertrophied and thickened. The muscularis may be normal or thickened by dense connective tissue infiltration. The vascular changes show obliterative endarteritis and perithelial infiltration of lymph and plasma cells. The cellular elements of the connective tissue are of the epithelioid type. Giant cells are sometimes seen, leading to the mistaken diagnosis of tuberculosis. Circumscribed collections of lymphocytes and plasma cells surrounded by a thin connective tissue capsule are described as miliary gummata. There is no surrounding inflammatory reaction, no necrosis nor caseation. Discovery of the specific organism in the tissues would clinch the diagnosis, but they are absent as a rule. They have been reported only once in the acquired form of the disease (McNee).

In the course of a review of 18,000 roentgen examinations of the gastrointestinal tract in this clinic 48 cases were noted in which syphilis was suspected either from the clinical or the roentgen findings. Of these, 32 can be eliminated either by operative findings or by their characteristic clinical course; 20 were operated upon. The findings were, cancer 8, ulcer 7, benign tumor 2, trauma by corrosive 1, gall-bladder disease 1, and stricture of the esophagus 1. The Wassermann reaction was positive in cancer 1, ulcer 1, and trauma 1. Of the 12 not explored, 4 were obviously malignant, 3 dying in a short time and 1 not reported; 4 had characteristic ulcer symptoms and were more or less relieved by appropriate treatment; 2 were diagnosed appendicitis, 1 salpingitis and 1 gall-bladder disease. The Wassermann was positive in one ulcer and one appendicitis case. The other 16 were all positively syphilitic. In 10 of these the evidence is so strong that I believe we can accept them as positive syphilitic lesions of the stomach. In 4 the picture is very suggestive. The other 2 I believe to be cases of coincidene benign ulcer in syphilitics although the evidence of an active syphilitic infection is so positive that it cannot be ignored as a possible etiological factor in the gastric condition.

DESCRIPTION OF THREE TYPICAL CASES

CASE 1. A. McD., male, aged forty-eight. Denies infection. A sailor from the age of fifteen to thirty-three. For two years

had epigastric pains immediately after food. A "tight, swelled up" feeling often quite severe; usually in the mid-line. Three months ago began to have cramp-like pains in abdomen just above the umbilicus. Very severe at times. Pain is relieved by passing gas or feces or by catharsis. Bowels were constipated. For the last six or seven weeks has had periods of mild diarrhea. No bloody nor tarry stools. Never vomited. Belched considerable gas. Takes less food than usual from fear of distress. Likes meat but is afraid to eat it. Distress is not relieved by soda or food. Has lost 40 lb. Does not look very sick or cachectic.

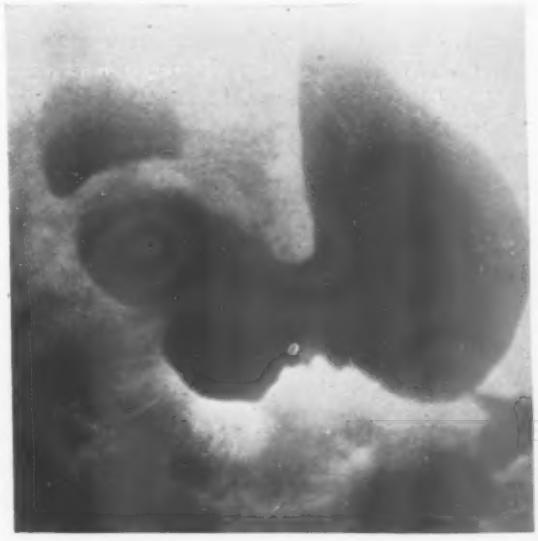

FIG. 2. Case II. Shows beginning hour-glass deformity.

Gastric analysis shows absent HCl; no blood. Wassermann test strongly positive. Clinical diagnosis, peptic ulcer or malignant disease.

Roentgen Findings. No delay. Irregular peristalsis, at times vigorous. Small annular filling defect in pyloric end of the stomach. Apparently some difficulty in emptying. Local tenderness. Probably malignant disease.

Surgical Findings. Antrum shows a tubular mass 10 cm. long with a narrow lumen. Not hard like typical cancer but suggestive of malignant growth. Excised. Good recovery. Discharged relieved in good condition. Reentry and operation about one month later for intestinal obstruction. Died, postoperative pneumonia.

Pathological Report. Constricting ring just in front of the pylorus, will not admit index finger. On section this ring is composed of an irregular ulcer 3 to 4 cm. wide with slightly raised edges. The base not deeply excavated, covered with a greyish slough. A few soft nodes in the omentum. Microscopic examination shows a superficial ulceration of the mucosa. The underlying submucosa is composed of vascular, cell-rich connective tissue infiltrated with wandering cells, a majority of the plasma type. The connective tissue does not extend to the muscular coat. There is no necrosis. The process is not like the usual chronic ulcer. There is no evidence of malignancy. Might be a healing process in a gumma of the submucosa.

FIG. 3. Case III. Shows extreme hour-glass contraction.

CASE II. M. W., female, aged forty-three. Married. One child died at seven months of "water on the brain." One miscarriage of twins. Two subsequent children well. For about two years had stomach trouble, with gradual onset of sharp epigastric pain immediately after food with nausea and relief by vomiting.

Soda gives no relief. Cannot eat potatoes, meat or eggs. Much gas. Pain has become more steady consisting of gnawing and feeling of fullness most marked under the left ribs. Appetite is poor or restrained by apprehension. No blood in vomitus or stools. Has lost 35 lb. Is rather thin but not markedly cachectic. Gastric analysis shows absent HCl; no blood. Wassermann test strongly positive. Clinical diagnosis, malignancy.

Roentgen Findings. Stomach low, peristalsis sluggish. Tone fairly good. No delay. A suggestive irregularity in the gastric media. Second examination three weeks later shows the filling defect in the media more distinctly. The pylorus was regular and the contents passed very freely. The first portion of the duodenum was large but normal in outline. The appearance is that of a malignant lesion in the gastric media.

Surgical Findings. Stomach large and low. An ill-defined, whitish scar seen on anterior surface near the lesser curvature. The area felt slightly indurated. Several enlarged glands along the greater curvature. Liver negative. About one-third of the stomach was excised.

Pathological Report. A cross section of the stomach about 10 cm. along the greater curvature. Lesser omentum adherent to the lesser curvature. On opening the stomach there is a superficial loss of substance in the mucosa with an irregular serpiginous outline. The edges are sharply marked off and the surrounding mucosa shows no induration. The surface of the ulcer is covered with a dirty greyish slough and the walls about and underlying it are very much thickened. There are a number of soft nodes in the omentum. Microscopically, the submucosa is greatly thickened by young connective tissue in which there are focal collections of plasma cells. Occasionally small foci of epitheloid and giant cells. Most of the small blood vessels show proliferation of the endothelium. A vascular connective tissue is also present in the muscular coats, but much less abundant. There is a considerable amount of it under the peritoneum. The mucosa contains a superficial ulceration to which a necrotic exudate is adherent, and along the deeper portions of this exudate is a zone of epitheloid cells with an occasional giant cell. The submucosa underlying the ulcerations is highly vascular and is intensely infiltrated with wandering cells. This cellular infiltration in the submucosa is equally marked where the mucosa is still present. These appearances strongly suggest syphilis although tuberculosis cannot be excluded. Levaditi sections show no *Spirochaeta pallida*. There is no evidence of malignancy.

Case III. K. D., female, aged fifty-eight. Six years ago had a "nervous breakdown" during which for a period of five or six months she had stomach trouble when foods caused colicky pains lasting for a few minutes. Appetite was poor. Did not vomit. No further trouble until five months ago except occasional periods of diarrhea lasting two or three weeks, becoming more frequent during the last two years. The worst of these attacks was about one year ago and at this time she noticed a few unusually dark stools. Five months ago foods again began to cause distress and pain. Appetite became poor. During the next two months and somewhat less since, she has felt an almost constant sensation of a lump in the epigastrium. Three months ago she went on a bread and milk diet and medicine by order of her physician, with considerable relief. After about one month she became nauseated and vomited for the first time. During the following month she had increasing distress after food and difficulty in eating and vomited more often and felt weaker. Since then her choice of food has been very limited. Most foods cause immediate distress and vomiting. Now has no severe pain. Became weaker in the last few months but had periods of improvement. Has lost 40 lb. Looks very emaciated. Under antisyphilitic treatment for about a month she felt considerable relief and seemed to improve a little but although her appetite was better she could not retain any solid food and only very little of anything. Gastric analysis showed absent HCl; no blood. Wassermann test strongly positive. Clinical diagnosis, syphilis or cancer.

Roentgen Findings. Liquid barium meal passed out of the stomach in normal time. The stomach was very small and deformed.

The deformity consisted of an extreme contraction of the shadow in the media which showed only as a slender tube occupying nearly one-third the length of the organ, connecting an inferior and a superior sac, the superior somewhat the larger. A third, much smaller sac or pouch was seen projecting backward from the narrow media just above the inferior sac and connected with it by a short constriction wider than the main constriction above. The lumen of the constriction was so narrow that it was hardly conceivable that anything but liquids could pass. The capacity of the whole stomach was much diminished. The pylorus appeared incompetent and the lower sac emptied itself very quickly. The first portion of the duodenum was distended but was normal in outline —definite hour-glass stomach of atypical appearance. May be an old benign ulcer with unusually marked contraction or a contracting syphilitic lesion.

Surgical Findings. The stomach was very much contracted especially in the middle portion corresponding to the roentgen picture. The walls in this region presented a thickened, rather soft, tumor-like appearance. This had not the characteristic feel or appearance of either cancer or old ulcer. The median portion was resected and the superior and inferior sacs united.

Pathological Report. A cuff-shaped area of stomach measuring 6 cm. along the greater curvature. The mucous surface is superficially ulcerated with islands of intact mucosa in its midst. The walls are thickened. Microscopical examination shows superficial erosion of the mucous membrane and infiltration with wandering cells. There is marked thickening of the submucosa which is about three times that of the muscular coats. It is composed of a loose connective tissue richly supplied with large tortuous blood vessels with occasional focal collections of wandering cells. There is no extensive proliferation of the endothelium. The muscular coats show slight fibrosis. There is no positive evidence of syphilis. The microscopic appearances resemble those of the stomach found in patients with active syphilis.

The following two tables summarize briefly the suggestive findings in 16 cases divided according to the significance of the records into 10 probably syphilitic and 6 in which a syphilitic etiology cannot be ignored.

CONCLUSIONS

The condition is a late manifestation of syphilis. It is not recognized in its early stages and early pathology is not seen.

It is a rare condition but probably not so uncommon as has been supposed.

The diagnosis rests upon history of infection, positive Wassermann reaction, the demonstration of a gross gastric lesion and cure or definite improvement under antisyphilitic treatment. Absence of history or signs of syphilis and a negative Wassermann reaction do not exclude nor does a positive Wassermann reaction prove absolutely the specific nature of the condition.

The possibility of syphilis should be considered in atypical cases and those resisting accepted methods of ulcer treatment.

The symptomatology is very suggestive, resembling benign ulcer with the chemical and roentgen findings of cancer. Its course begins irregularly and tends to become continuous. Pain or distress immediately after food, not relieved by alkalies, aggravated by food, and relieved by vomiting. Appetite good. A progressive course with marked loss of weight unaccompanied by the degree of cachexia and weakness seen with cancer. Palpable tumor is uncommon. Anacidity or achylia is the rule.

The gastric involvement is generally extensive.

Antispecific treatment gives marked relief in all but very advanced cases. The cicatricial contractions do not disappear under treatment and surgery is often indicated in those with extreme deformity or obstruction.

Final proof is difficult, and presumptive evidence should be considered grounds upon which to give the benefit of antisyphilitic treatment.

Anatomically the lesion consists of multiple irregular ulcers of gummatous origin with thickened submucosa, cicatricial contractions, vascular changes, perivascular infiltration, and diffuse infiltration of leucocytes and plasma cells.

SUMMARY OF STRONGLY PROBABLE CASES

Case No.	Age	Duration	Loss of Weight	Pain	Vomiting	Wassermann	Melena	Gastric HCl	Palpable Mass	Roentgen Findings	Surgical Findings	Pathology	Remarks
1	48	2 yr.	40 lb.	Dull	With relief	P	o	o	o	Annular defect in antrum like cancer	Induration like cancer	Not ulcer nor cancer	Died, pneumonia
2	43	2 yr.	35 lb.	Acute	With relief	P	o	o	o	Defect in media like cancer	Induration in media, excised	Not ulcer nor cancer ? syphilis ? tuberculosis	Discharged, relieved, disappeared.
3	58	6 yr.	40 lb.	Dull	With relief	P	o	o	o	Hour-glass	Induration in media, excised	Not ulcer nor cancer ? syphilis	Very weak. Did not survive operation.
4	54	3 yr.	40 lb.	Dull	With relief	P	o	o	o	Hour-glass	Induration in media, no ulcer	Not ulcer nor cancer ? syphilis	Chancre at 20
5	32	4 yr.	60 lb.	Acute	With relief	P	o	o	o	Hour-glass	Induration in media, no ulcer	No examination	Chancre at 20. Well 12 yr. later but roentgen examination shows persistent deformity.
6	56	4 mo.	34 lb.	Dull	None	P	o	o	?	Defect in media like cancer	Induration like ulcer	Not ulcer nor cancer	
7	34	2 mo.	Much	Dull	With relief	P	o	o	o	Annular defect in antrum like cancer	Induration in antrum like cancer	Two nodes not malignant ? syphilis	Chancre at 24. Well 9 yr. later but roentgen examination shows persistent deformity.
8	44	2 mo.	Rapid	Dull	With relief	P	?	?	o	No record	Induration in antrum like cancer	Not ulcer nor cancer	
9	22	3 yr.	50 lb.	Severe	With relief	P	o	o	o	Hour-glass	None	None	Died 1½ yr. later. Mother syphilitic.
10	36	2 yr.	54 lb.	Severe	With relief	P	o	o	o	Water-bottle	None	None	Antisyphilitic treatment. Well 8 yr. later.

SUMMARY OF SUGGESTIVE CASES IN WHICH SYPHILIS CANNOT BE RULED OUT AS A POSSIBLE CAUSE OF THE GASTRIC FINDINGS

Case No.	Age	Duration	Loss of Weight	Pain	Vomiting	Wassermann	Melena	Gastric HCl	Palpable Mass	Roentgen Findings	Surgical Findings	Pathology	Remarks
11	45	2 yr.	50 lb.	Dull	With relief	P	P	o	o	Defect in media like cancer	None	None	Specific treatment; 7 mo. later physician reports free from symptoms.
12	28	1 yr.	55 lb.	Dull	With relief	N	o	P	o	Hour-glass	Induration and thickening not like ulcer. Submucosa indurated.	Thick submucosa with large blood vessels. Not malignant.	Chancre 13 mo. ago. Specific treatment. Died suddenly 3 wk. after discharge.
13	54	6 mo.	15 lb.	Dull	With relief	P	P	?	P	Defect in antrum like cancer	Induration in antrum probably cancer.	None	2½ yr. later feels well. Eats everything. Working. Definite signs of gall-bladder disease.
14	35	3 yr.	40 lb.	Dull	With relief	P	P	o	o	Defect in antrum like cancer	None	None	Improved under salvarsan. Disappeared.
15	24	5 yr.	?	Severe	With relief	P	P	o	o	Defect in antrum with patent pylorus	None	None	Improved under salvarsan but still some gastric symptoms one yr. later.
16	27	?	?	Dull	With relief	P	P	P	o	Defect in antrum with some delay	None	None	Improved under salvarsan; 9 yr. later well. No stomach trouble.

Roentgen evidence is not characteristic but is valuable in determining the location and extent of the lesion and should be used in conjunction with all other possible evidence in deducing the probable diagnosis.

Demonstration of the specific organisms in the tissues would be the final proof but must not be expected.

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A BRIEF ANALYSIS OF SOME IMPORTANT FACTORS IN THE BIOLOGICAL ACTION OF RADIATION*

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IN the use of radiation for therapeutic purposes there are physical, chemical, and biological aspects which are closely interrelated. While the physical problems have received considerable (but still insufficient) attention in recent years, the chemical and biological questions have been in the background. It is the purpose of this paper to call attention to some general considerations relative to the biological action of radiation and its bearing on radiation therapy. The writer, being a physicist, cannot discuss this subject from the point of view of the biologist. Accordingly the points mentioned are those which would occur (and certainly some, if not all, of them must have occurred) to the scientific worker in the field of radiology.

In any natural phenomenon there are usually many factors involved. In mathematical language these constitute the "variables." A complete scientific investigation of the phenomenon consists in determining the quantitative relations existing among all the variables. In any given practical problem it is convenient to consider explicitly one of the variables as dependent on all the others. Thus if we wish to study the passage of electricity through a wire we have three factors involved: (1) the voltage applied, (2) the resistance of the wire, (3) the resultant current. If we wish to determine how the current varies with the voltage and the resistance of the wire, then the current represents the dependent variable and the voltage and resistance the independent ones. The relation among the variables in this particular case is the well-known Ohm's Law:

$$\text{current} = \frac{\text{resistance}}{\text{voltage}} \text{ or } C = \frac{R}{V}.$$

We could equally well consider the voltage as the dependent variable, in which case Ohm's Law would be expressed as follows: $V = CR$. The two, of course, are different only in form.

We wish to bring out now a point of the utmost importance in all experimental work. In the above example, have we considered all the factors which may influence the phenomenon? We have said nothing about temperature, pressure, medium surrounding wire, material of wire, type of current, etc., which of course may modify the relation among the three variables we have considered. It is known, for instance, that the resistance of a wire in general varies with the temperature, and that the passage of a current through a wire heats it. Evidently then this effect must be taken into consideration. This is done by stating that the value of the resistance is the one corresponding to the temperature of the wire while the current is flowing. A still greater influence is exerted by the type of the current, that is, whether it is continuous, pulsating, or alternating. If we are not dealing with a continuous (direct) current, then Ohm's Law does not hold at all unless we extend the meaning of the term resistance to include the effects of inductance and capacity.

In any practical problem there is usually a large number of factors involved. Of these, however, some are of more interest to us than others. In such a case we limit our experimental study to a few and take care of the others by holding them constant throughout the investigation. The important factors themselves may be treated in the same manner in order that while the relation between two of the variables is being determined the others may be kept constant at definite values. This principle, which makes possible the study of complicated phenomena, may lead to very serious errors if it is not properly applied. The chief difficulty arises from the fact that the limitations imposed by this procedure may be overlooked and unwarranted generalizations made. Errors may also be introduced by failure to recog-

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nize the fact that some factors may have been held constant unintentionally during the experiments, and therefore, one may reach the false conclusion that they exerted no influence.

The above considerations apply to all experimental work in which a relation between "cause" and "effect" is sought. Their practical application is relatively simple in physical experiments and relatively difficult in biological experiments. This has given rise to the misconception that physics is an exact science while biology is not. There is really no such thing as an inexact science, for in that case it is not a science at all. The scientific method of investigation is always the same, and the fact that in biological phenomena there are usually more unknown factors, or more factors which are difficult to control, than in physical phenomena, does not alter the method. It simply means that more care and more discrimination must be exercised. On the other hand, while the general method is the same, the particular mode of attacking a problem may be quite different. Biological investigations must be largely statistical in character, while in physical experimentation the statistical basis is not so much in evidence, although it is always there.

Before proceeding to the analysis of some biological problems we shall consider briefly the important question of quantitative studies and their precision. When a new phenomenon is discovered usually only qualitative relations among the important factors entering into it are established at first. Thus in the passage of electricity through a conductor one would find out at first that, other things being equal, the higher the voltage, the larger the current in the wire; or, the larger the resistance, the smaller the current. Then more extended investigations would reveal the actual quantitative relation, viz., *how much* a certain increase in voltage will increase the value of the current, etc. If sufficient experimental data are thus collected we may discover general relations among the factors which enable us to *predict* the value of one of the variables if the values of the others are known. It is only then that the information becomes of real practical value.

No quantitative study is possible without mensuration, and this presupposes the ability to determine the magnitudes of the different factors involved, which in turn requires certain units. In physics definite systems of units and standards have been established, reliable measuring instruments have been developed, and therefore quantitative studies are *relatively* simple. It is true, nevertheless, that the majority of measurements are made by indirect means. The science of biology is still largely descriptive and qualitative. Quantitative studies have not received very much attention, and even the means for carrying them out are lacking in a large measure. Accordingly, one is limited almost entirely to indirect methods of measurement.

It is commonly supposed that physical measurements are "exact." In reality every measurement of any kind is in error by a small or a large quantity, depending on conditions. For this reason in formulating general relations from our experimental data it is very important to state the precision with which they may be expected to apply. In biological problems especially, this may not be a simple matter, and considerable care must be exercised. In undertaking an experimental research one should decide what precision is *necessary* and *sufficient* for the purpose in view. The experimental procedure and the instruments used will be governed largely by this consideration. Since the greater the precision sought, the more complicated the investigation becomes, it is evident that a great deal of time and energy may be saved by making the precision of the results conform with the practical requirements of the problem at hand.

We have already mentioned the notable lack of units and means for measurement of biological quantities. This makes quantitative studies in this field particularly difficult but still not impossible. We shall examine now some specific problems of interest to radiologists and shall indicate certain general lines of attack.

To Determine the Skin Erythema Doses for a Radium Applicator Using Different

Filters: Since we are speaking of a definite applicator, we may consider the amount of radium, its distribution, and distance from the skin to remain the same. The problem, then, is to determine the quantitative relation between the filtration and the time of exposure, maintaining the biologic effect, i.e., the skin erythema, always constant. It is evident that no special precautions must be taken to maintain the amount of radium, its distribution, and the distance from the skin constant in the course of the experiments. On the other hand, to make sure that the biologic effect is quantitatively the same is not a simple matter. We shall analyze this part of the problem in detail.

We shall assume that the particular applicator at our disposal is made in such a way that by suitable changes in filter we may get a radiation which is predominantly beta, or wholly gamma, or any intermediate mixture. In the literature one finds frequent reference to the "caustic" action of beta rays, and the "selective" action of gamma rays. Must this be taken into account in our experiments? Inasmuch as either type of radiation is capable of producing what we call an erythema, we need not, for the solution of the present problem, concern ourselves with the *mechanism* of the biological action of either.

The next point to consider is what we shall mean by "skin erythema." This question requires careful consideration. The wording of the problem gives us no definition of skin erythema, and there is none that is generally accepted. Accordingly we are at liberty to choose any definition we please, *provided we maintain it the same throughout the experiments.* But in order to fulfill this condition it is necessary to have a means of measuring skin erythema, and yet none is available. We are confronted with the same situation that a physicist would be if he had to carry out experiments at a constant temperature and he had no thermometer or other temperature measuring instruments. To overcome this difficulty we proceed as follows: It is true that we have no objective means of determining the intensity of an erythema, but we can tell quite definitely whether one is or is not present. This is especially true if the outline of the erythematous area is sharp, which condition can easily be met by a suitable experimental arrangement. Therefore, we may use the threshold value of the erythema as a standard of comparison in the solution of our problem. The experiments consist in determining the time of exposure required to obtain the threshold erythema for each filter we wish to use.

If we did not know it already, we would soon find in the course of the work that all individuals do not exhibit the same sensitivity to the rays, and that there are variations between different skin areas of the same subject. This introduces further difficulties. The method employed to overcome them depends largely on the object of the investigations, which in turn determines the precision required in the results. Subsidiary experiments must be made to determine whether the variations referred to fall within the allowable limits of error. If they do not we must resort to classification. Thus we may divide the skin into several areas and make our tests on corresponding regions in different individuals. We may further group the subjects into male or female, fair or dark, young or old, etc. The precision of the results in each class will depend to a considerable extent on how accurately the classification is drawn, and on the number of tests made. In any case, it will be seen that a statistical method is made use of, and that, therefore, the results are averages even for each class.*

Since experiments of this kind require a great deal of time, it is important to arrange them in such a way as to derive the maximum information for the effort made. In other words we should try to make the results as general as possible consistent with the inherent limitations of the problem. It is here that judgment and experimental insight play an important part. For instance, in the problem under consideration we should decide at the outset what are the minimum and the maximum filters that anyone would want to use. Then we should take *at least* two

*A further discussion of this problem may be found in two publications from our laboratory.[1, 2]

more intermediate values, and carry out the experiments for the four (or more) thicknesses of the same filter. This would enable us to represent the results graphically by means of a curve, from which we could obtain, without further experimentation, the results for any other filter within the limits of the curve. The number of points necessary to determine the curve with fair accuracy depends on its shape. For a simple smooth curve, at least four points, properly spaced are required, but five or six would be better.

The experimental results obtained in this manner apply only to the applicator and the amount of radium chosen, so that their usefulness is quite limited. We could go through the same process for any other applicator we may wish to use and obtain the desired information. It is evident, however, that if many applicators are to be investigated in a similar way the experimental work will be very long. It is better, therefore, to plan the work so as to obtain further generalizations covering all applicators within a certain range. This extension of the problem may be divided into three parts:

(1) Variation of the amount of radium in the same applicator.

(2) Variation of the shape and size of the applicator.

(3) Variation of the distance between the radium and the skin.

To simplify the work we may change the variables in the problem. In part (1), we could take the filter as the independent variable (as before) and the amount of radium as the dependent variable, keeping all other factors, including the time of application, constant. This, however, would not be very convenient. We may overcome this practical difficulty and further simplify the work by a change of variables. Bearing in mind the object of the experiments, it will be seen that the desired information may be obtained in the following way: Other conditions being the same, the amount of radiation reaching the skin depends on the product of the quantity used and the time of exposure. It does not follow, however, that the biologic effect will depend on the milligram-hours, irrespective of the amount of radium employed. We must determine, therefore, what effect this has. Again we set the limits of variation of the quantity of radium in accordance with practical considerations. Then maintaining the filtration constant we vary the amount of radium and the time of exposure so as to obtain the same threshold erythema as before. We obtain thus a relation between quantity of radium and milligram-hours for the filter and the applicator used. We cannot announce *a priori* that the same relation obtains for other filters, but it is not unlikely that such is the case. Accordingly, it is advisable to do this work with two separate filters, one at the lower and one

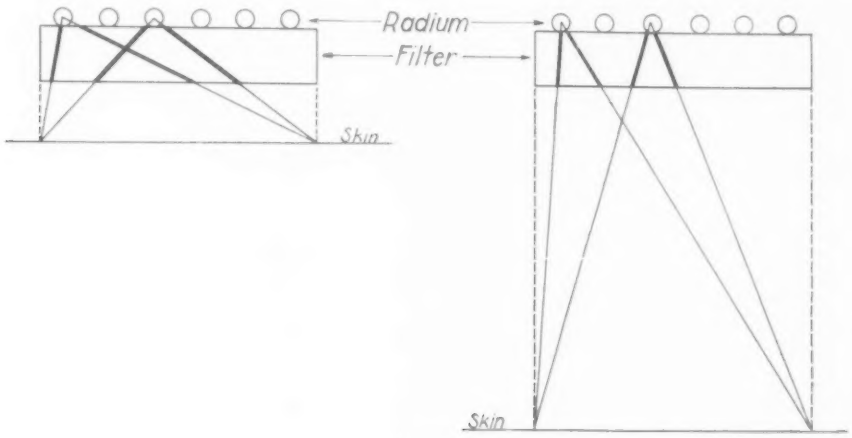

FIG. 1.

at the upper limit of the range decided upon before. If the relation is the same, within the limits of experimental error, then it is reasonable to assume that it is the same for all filters in that range. If it is not the same, a number of intermediate filters must be used before any generalization may be made.

Coming to parts (2) and (3) of the problem we find that these are mainly physical in character. In fact there are only two biological considerations involved: (*a*) The area of the skin surface irradiated may exert an influence on the production of erythema, even if the amount of radiation per square centimeter of the skin is the same. (*b*) A variation of the size or distance of the applicator may vary the quality of the radiation reaching the skin. Thus, if the particular filter under consideration allows an appreciable part of the beta radiation to pass through, the average quality of the radiation effective on the skin in the two cases is different. This is evident from Figure 1, in which it will be seen that the thickness of the filter traversed by some of the rays is not the same for the two distances shown, although the thickness of the metal plate is identical in both cases. Allowance must be made for the change in quality on the basis of biological experiments. In attempting to solve parts (2) and (3) it is simpler to work out the physical data first, taking all the necessary precautions, and then check up the results by supplementary biological tests.*

The discussion of this example, while rather long, is hardly complete. There are many minor points involved which had to be omitted for the sake of brevity. The main idea we wish to convey, however, is that the lack of an objective means to measure the intensity of the skin erythema does not prevent the solution of a good many problems related thereto, on a quantitative basis and with as great a precision as we desire. In addition, we wish to point out that by properly planning the experiments we can make the results of more general applicability without increasing unduly the experimental work.

* Two papers from our laboratory give further information on this problem.[1, 2]

Some Factors Which May Influence the Susceptibility Ratio between Different Tissues.

We shall proceed now to the consideration of "differential action." It is known that some types of living tissue are more easily affected by "radiation" than others. This has given rise to the idea that gamma rays, for instance, exert a selective action on some tissues. It is unfortunate that such nomenclature should have been employed, because it is misleading. All types of cell *are* affected by radiation if the dose is sufficiently large. It is appropriate, therefore, to speak of the differential action of radiation upon living tissues.[4] Looking at the question from the point of view of cell reaction we may say that tissues differ in susceptibility to "radiation." There is no means of determining the absolute susceptibility of tissues, and even the relative susceptibility is unknown except in a qualitative way. But let us assume that two tissues, A and B, have susceptibilities S_A and S_B respectively. Then we may indicate the relative susceptibility of the two by the ratio $\frac{S_A}{S_B}$, which we may call the susceptibility ratio R. If A is a tumor and B the surrounding normal tissue, the larger R is, the more susceptible is the tumor with respect to its surrounding tissues, and the simpler becomes the problem of treating the patient. It is evident that if we can influence this ratio favorably by any means at our disposal, we shall take a considerable step forward in radiation therapy.

The effect of radiation on living tissues depends on:

(1) A large number of biological factors.
(2) The quality of the radiation employed.
(3) The distribution of the radiation in the tissue.
(4) The spacing of the irradiations with respect to time.
(5) The intensity of the radiation.
(6) The time of exposure.
(7) The quantity of the radiation absorbed per c.c. (This is really included implicitly in the preceding factors.)

If two tissues are different then some of the biological factors are not the same, and we may say *a priori* (from (1) above) that in general the effect of radiation on the two will not be the same, even if factors (2) to (7) are identical. In general, therefore, we have a different susceptibility ratio, R, for each pair of tissues considered and each biological action. This ratio may be influenced by some or all the other factors. It is our object now to analyze this problem and to indicate certain lines of attack for its solution. We shall begin with the influence which the quality of radiation may have on the susceptibility ratio.

Since this question has been discussed by Russ[5] in a recent paper, it may be well to summarize his work. Russ carried out numerous experiments using "soft" and "hard" roentgen rays separately (the reader is referred to the original paper for the details on the quality of roentgen rays employed), and two types of tissue, a definite rat tumor and the skin of the animals. He measured the dose of radiation carefully by means of an ionization instrument. The results were as follows: (*a*) To produce the same lethal effect on the tumor with hard roentgen rays the dose as measured by his instrument, had to be 2.6 times larger than the soft roentgen-ray dose; (*b*) to produce the same effect on the skin with hard roentgen rays the dose had to be 6 times larger than with soft roentgen rays. From these figures we find that the susceptibility ratio R (as we have defined it) for these two types of tissue varied $\frac{6}{2.6} = 2.3$ times when the radiation was changed from "soft" to "hard." In this case at least, the susceptibility of tumor cells is greater, as compared with the susceptibility of skin cells, for the hard than for the soft roentgen rays. If the same relation applies even to one type of human tumor and the skin, then it is desirable to use hard roentgen rays for the treatment on this basis alone, irrespective of any other advantages. Accordingly the importance of experiments of this type is obvious.

We wish to point out that the difference in the "doses" of soft and hard roentgen rays to produce the same effect on the same type of tissue (either tumor or skin) as indicated by ionization measurements, is of little practical value in therapy. The important point is that changing the quality of the radiation seems to change the susceptibility ratio of the two tissues considered above. If the ratio did not change, then by expressing dosage in terms of a suitable biological unit we could expect correspondence between the dose and the effect produced, independently of the quality of the radiation.

Since the problem is of such practical importance, it is well to inquire whether Russ's experiments really establish the variation of the susceptibility ratio with respect to the wave length of the radiation. It is the opinion of the writer that a definite proof has not been given, although the experimental results are suggestive. The uncertainty arises from two sources: (1) The thickness of tissue used in the tumor experiments was 1–2 mm. while in the skin experiments the backs of the rats were irradiated and no one knows just what thickness of tissue was involved in the skin reaction observed. If it was different from 1–2 mm., then the *distribution* of the radiation in the tissue may have played an important part in the results. It is certain that in the case of the soft radiation the upper layers of tumor must have received considerably more radiation than the layers on the opposite side of the slab. This means that in order to kill all the cells, the majority must have been overexposed. The same occurred in the case of the skin experiments but the extent of the overexposure would depend largely on the thickness of the tissue involved in the reaction. If it was considerably less than 1–2 mm. one might attribute the differences found by Russ (at least in part) to the difference in the distribution of the radiation. (2) The second source of uncertainty is to be found in the method adopted to determine equality of skin reaction. This involves the estimation by the experimenter of the degree of the reaction largely by subjective means. In view of the fact that in such experiments a considerable variation in the dose is necessary in order to observe a definite difference in the skin reaction, it is evi-

dent that the method does not lend itself to quantitative studies. This uncertainty might have been reduced to a minimum by using the "threshold" reaction for the comparison of doses, as already described in this paper. Russ made use of this principle in determining the lethal doses for the tumor tissue.

The above objections may be overcome by modifying the experimental procedure. The point to be determined is whether the susceptibility ratio varies with the wave length, and, if it does, it is important to know how it varies. For the experiments we need two tissues of different type, and radiation of at least two distinct qualities. In order that the results shall be reliable, it is indispensable that all other factors shall be kept constant throughout the experiments. We may choose for the two types of tissue a definite rat sarcoma and a definite mouse carcinoma, and we may use Russ's technique for the determination of the lethal doses. By taking slices of tissue of the same thickness for all the tests we would avoid the uncertainty mentioned above. If we wish to use the skin as one of the tissues we may approximate equality of conditions by irradiating the ears of rabbits and slices of tumor tissue (either rat sarcoma or mouse carcinoma) of corresponding thickness. For the skin experiments the doses should be so adjusted that the desired (threshold) reaction shall appear on the far side of the rabbit's ear, that is, on the emergent side of the radiation beam.

Bearing in mind the fact that investigations of this sort require a large number of tests in order to treat the data statistically it is convenient to use insects as biological material. The experiments of Davey,[6] Mavor[7] and others, have shown that a considerable degree of precision can be obtained by employing large numbers of insects for roentgen-ray studies. To investigate the influence of quality on the susceptibility ratio one may determine the dose of radiation required to *sterilize* 50 per cent of a group of fruit flies and the dose necessary to *kill* 50 per cent of a similar group. The cells involved in the two reactions are different and one could obtain a susceptibility ratio for radiation of any desired quality. Since the insects are small the question of the distribution of radiation in the medium would be of very little importance. Furthermore, one may study the variation of the susceptibility ratio between cells of the same type, but irradiated at different stages in the development of the flies.

The radiologist may question the practical utility of experiments with insects. But if the results are interpreted properly a great deal of useful information may be obtained in a simple way. Thus let us suppose that we have carried out the experiments outlined above, and that we have determined the effect of wave-length on the susceptibility ratio of several types of cell. We may find that in every case where a more susceptible cell and a less susceptible one are compared that the difference in the relative susceptibility is enhanced by the use of more penetrating (or harder) radiation. If we find this to be true without exception in several determinations, we have a good reason to suppose that it may be true in general biological reactions. It does not follow, of course, that no exception will ever be found, but in the meantime we may use this as a basis in changes we may wish to make in radiotherapeutic technique. If the above-mentioned conclusion were true it would be advantageous to use highly penetrating radiation for the treatment of tumors which are known to be more susceptible than the skin or surrounding normal tissues. On the other hand, for more resistant tissues we should use a softer radiation. The clinical results obtained after a careful investigation would determine whether the same relation obtains in radiotherapy. The important point is that the results of simple biological experiments are made to serve as a basis for clinical studies. There are so many possible ways in which we may attempt to improve our clinical results, and it takes so long to find out whether one is better than another, that any indication of a promising line of attack is of considerable practical value.

We shall examine now the influence of the spacing of the irradiations with respect to time, on the susceptibility ratio. By

"spacing with respect to time" we mean the arrangement of the irradiations as regards quantity, duration, and intervals between exposures, if divided doses are administered. This question has received considerable attention during the last few years on account of the claims made for the massive dose technique which originated in Erlangen. It is not unusual to hear the exponents of the divided dose method say that by fractional irradiations they can deliver a larger dose to the tumor than by the "massive" treatment. This statement as it stands is incorrect for more reasons than one. In the first place, it is not a question of how much radiation one can get into a tumor, but of the effect which it produces. Then it is important to know what other effects are produced, and this is where the susceptibility ratio comes in. Since in general other tissues besides the tumor are irradiated the results will depend to a large extent on the relative effects in all the tissues. On the other hand, if the same final result can be obtained in two or more ways, there is one which is preferable from the point of view of the patient or of the radiologist.

To make our discussion more definite we may take a specific problem as an example. Let us say that we are dissatisfied with our present technique in the treatment of bone tumors. We decide to change the time spacing of the treatments to see whether we cannot improve our results. Since there are many clinical factors which are unknown or imperfectly known, but which may influence the results, for our study we have to resort to statistical methods and to classification. Let us say that we shall try the new technique on all adult patients in good general condition, having a definitely known tumor of the same type, in the same location and the same general history. It will be seen that this classification excludes the majority of patients with bone tumors who might present themselves for treatment. Such restrictions, however (and perhaps others), are essential in order to draw the proper conclusions from the results. Nor is this sufficient, for every change in technique we may wish to make must be tested out on a large number of patients in the same class.

Physical and anatomical considerations of this problem tell us that by using roentgen rays we cannot prevent the irradiation of normal tissues in the neighborhood of the tumor with doses not far removed in magnitude from the tumor dose. For this reason the susceptibility ratio is of particular importance here. The tissues in the field of radiation are, tumor tissue of a definite type and normal bone, marrow, muscle, connective tissue, blood vessels, skin, etc. Between the tumor and each of the latter there is a susceptibility ratio which may be less than one, one, or greater than one for a given set of conditions of irradition. The success of the treatment depends on the combined result of all these ratios and a number of clinical factors referring to the patient as a whole.

Suppose that in our previous treatments we have used the massive dose technique giving as much radiation in a short time as the skin would stand. If we feel that the tumor dose was not sufficient in the past to cause a disappearance of the tumor, we cannot increase it by increasing the skin dose. It may be possible, however, to increase the *relative* effects in the tumor without exceeding the limit of toleration of the skin, by a suitable spacing of the treatments. Let us say that instead of giving the full dose in one day we shall treat the patient every other day for two weeks. Each day the patient would be treated in exactly the same way as in our previous cases except that the dose would be smaller. This is very important because if we wish to investigate the effect of the spacing of treatments we must have all other factors the same as before. Accordingly the voltage, the filter, the number of ports of entry, etc., must be the same. But how large a dose can we administer every other day without injuring the skin unduly? Our general experience would tell us that we can give a larger total dose in intermittent treatments than in one treatment, but we do not know how much larger it can be. Of course, we may start with what in our judgment is a safe dose, and gradually increase it. However, it will take a long time to determine the equivalent total skin dose in fractional treatments, and yet we cannot really

carry out the investigation intelligently until we know this. Let us assume that we have solved the preliminary problem of skin doses for treatments given every other day during two weeks, and that our main clinical study has shown a slight but distinct improvement in the results. We would feel then that we were working along the right lines and we would want to try a different spacing to effect further improvements. Accordingly we decide on giving treatments every other day, but for a period of one month. The question of what dose to give at each treatment comes up again.

Without prolonging this discussion further it is evident that the problem of skin doses has an important bearing on many changes in therapeutic technique we may wish to make. Every radiologist knows, however, that a great deal of time is required to establish the skin dose, even for one set of conditions of treatment. Parts of the problem can be solved by physical means but in general biological experiments are necessary. This is due to the fact that a correlation between dose and effect is what is really required. If we attempted to get the desired data by treating patients we would be greatly handicapped. Here again animal experimentation can be made to yield very useful information. The results could then be checked up on the patients in a comparatively short time.

Our discussion so far has covered rather sketchily the effect which the quality of the radiation and the spacing of the treatments may have on the susceptibility ratio. Time does not permit a further discussion of these factors nor even mention of the many others. We hope we have succeeded in bringing out two important points: (1) The necessity for the exercise of great care in experimental work of this kind, and (2) the value to the radiologist of properly conducted experiments on animals.

In conclusion, we shall say a few words about the future of radiology. The present technique is due almost entirely to chance, or to practical considerations. We use whatever amount of radium may be available, or the voltage and current our machine can deliver, and we have adjusted treatments accordingly. If we have obtained some good results it is perhaps by mere accidental coincidence. Our knowledge of the biological effects of radiation and the laws governing them is so limited that a rational basis for the treatments is lacking almost entirely. It may be that by chance we have already used the most suitable conditions and that, therefore, there will be no improvements in the results. However, we cannot take this for granted until we have tried fully a great many other possibilities. The work is still in its infancy and it is not illogical to expect that better knowledge of the subject will bring us greater success. The surest and quickest way to solve the general problem is through intelligent experimentation, and I hope that the radiologists in this country will encourage such work as much as possible.

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DISCUSSION

Dr. C. H. Viol, Pittsburgh, Penna. The statement was made yesterday that the beta rays from radium seem to have a more intense action than the gamma rays from screened radium. I believe it is the consensus of opinion that the gamma rays act only through the production of beta rays in the tissues so the difference is not so much as it may seem. The gamma rays act on the tissue only by reason of the beta rays they produce. Because the more or less local effect is due to the easily absorbed beta ray action, one jumps to the

conclusion that the two types of radiation are productive of entirely different effects.

I can only second Dr. Failla in his pointing out the numerous factors that enter into the physiological factor, and unless you keep certain of those factors uniform there will be much difficulty in differentiating the results.

Dr. Bernard F. Schreiner, Buffalo, New York. Dr. Failla referred to the fact that a large percentage of this work cannot be carried out by animal experimentation, and in this connection I wish to call attention to the article by Whipple which dealt with roentgen-ray intoxication. In experimenting upon the animal and treating the human we are dealing with two different organisms, especially from the standpoint of skin tolerance and body thickness. In the instances they reported in which they compared the affected intestinal mucosa it would be surprising if the dose given did not prove to be a lethal dose. It is perfectly possible that the intestines in those cases received 200 per cent of the human erythema skin dose, which necessarily would cause destruction.

Dr. George E. Pfahler, Philadelphia. I just wish to emphasize what Dr. Schreiner said. About two years ago I obtained some sarcoma tissue from Dr. Wood and carried out some experiments on white mice. One of the first things we did was to determine the erythema dose in a normal mouse, and we found it required six times the human dose to cause an erythema or loss of hair on the part of the mouse treated. I believe, therefore, that we are often misled by the statements that are sometimes made in experimental reports, that such and such an effect was produced with an erythema dose. I think this should be constantly kept in mind. I have never published the experimental work I performed, for I have never completed it, and never came to any conclusions, but I tried to treat the skin of the mouse as we do in the human subject and not the whole body. If we treated the whole body of the human being we would get a very different effect from that obtained in treating the tumor. In the mice, I inoculated the tumor and then treated that region, keeping the exposure more or less localized, as one would do in treating the human breast, and in that way it seems to me a more comparable conclusion can be drawn than when the whole body of any animal is treated.

Dr. Bernard F. Schreiner, Buffalo. I would like to add that this subject of the erythema dose in mice has been pretty well followed out, and that the skin of the mouse, judging from the depilatory effect, is approximately five or six times as resistant as the human skin. Relatively speaking, the intestine of the mouse has about the same susceptibility as the human intestine. Dr. Stenstrom at the Institute has recently carried out some experiments and found that the size of the skin field is a decided factor in the skin dose. Between a small field, 5 by 6 cm., and one 15 by 20 cm., there was a difference of 20 per cent in the time of exposure necessary to produce an erythema.

Dr. J. E. Gendreau, Montreal, Quebec. Suppose with a skin susceptibility of one and a tumor of three, the ratio between the skin and tumor sensitivity will be three. Is it possible to have different wave lengths act with the same factor on the skin and act more upon the tumor? Is it possible to conceive a shorter wave length acting with one over the skin and acting with four over the tumor? Then, does Dr. Failla think that all the gamma ray action upon the cells is due to the production of secondary beta radiation, or does he think the action of the gamma rays may be a direct one upon the cell?

Dr. Failla, closing. As to the animal experimentation, I wish to say that whether the proper conclusions are drawn from the experimental results or not is really the question. If proper conclusions are not drawn then the application of experimental work to therapy is wrong, and this depends upon the experience of the experimenter. Whether the conclusions can be transferred to the human from the animal has to be decided by the physiologist and the radiologist together. The experiments mentioned by Dr. Schreiner were not applicable to the human. If Dr. Whipple and his co-workers drew that conclusion they made a mistake. There are many experiments which can be made and which can be applied to treatment of patients by radiation. There are so many possibilities and so many different things that can be tried out upon animals, and the patients are so few in number. Furthermore, you wish to give the patient the best chance and use the things that are the most promising, and to my mind there is only one way to find this out and that is by animal experimentation.

In reply to Dr. Gendreau, there is a possibility of getting a variance and there is evidence to show that such is the case. Dr. Regaud's experiments were very interesting along that line, and also those of Dr. Russ, which I have discussed in my paper. Here, again, is where animal experimentation will help solve the problem.

Regarding the effect of gamma rays, whether they have a primary effect on the cell or whether the effect is due to the secondary beta rays, that is more theory than fact and I

cannot answer it one way or the other very definitely. From the physical point of view we know that the ionization is due to the secondary beta rays produced by the gamma rays. The physicists would conclude, therefore, that the biological effect is also due to the secondary effect of the gamma rays, but the problem is very complicated and definite conclusions of that nature should not be drawn until more information is available.

A COMPARISON BETWEEN THE FRENCH AND THE GERMAN "ERYTHEMA DOSE" AS MEASURED ON THE SOLOMON IONTOQUANTIMETER*

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SINCE the discovery of the therapeutic use of the roentgen rays numerous workers have endeavored to find a particular basis by which to establish measurements for practical dosage. The use of the roentgen ray for superficial therapy is to a great extent standardized but the question of dosage in deep therapy has been difficult of solution because of the variations inherent in the patients requiring deep roentgen treatment. When reference is made to the dosage given by the different operators it is practically impossible to identify the erythema doses given. Ever since the early attempt of Seitz and Wintz to establish a specific erythema dose, many attempts have been made to modify and simplify it so that this dose might be reproduced under all conditions. These efforts, however, have not proven satisfactory. Kroenig and Friederich, Warnekros, Voltz, Solomon, Regaud and others have advanced different standards for the erythema dose, and in practice, a variety of indicators has been used for designating this dose.

When the biological method was first used for measuring the erythema dose, the results were used as a basis for the subsequent mechanical methods. Workers in various countries, having found it extremely difficult to reproduce the so-called standard erythema dose of the Germans, have sought to establish another dose based on a more scientific and reliable procedure. Of the latter, that of Solomon appears to fulfill all the requirements for measuring the standard erythema dose.

Solomon's method consists of measuring the intensity of the delivered roentgen rays with a standardized apparatus. His iontoquantimeter consists of a measuring electroscope, a conducting rod and an ionization chamber. It is moreover standardized by a known quantity of radium.

The ionization produced by one gram of radium element in one second, placed at a distance of 20 mm., and screened with 0.5 mm. of platinum represents the unit R which is the time of fall of the leaf of the electroscope on the scale of the instrument for a given length of this scale. Solomon claims this to be an unequivocal method of comparing and measuring the intensities of beams of roentgen rays, and specifies a quantity which can be used as an international unit of roentgen-ray energy.

The German erythema dose varies with the various roentgen-ray workers. It is described as a dose which gives an erythema or reddening of the skin within a certain time limit which varies with the different authors. The French erythema is a radio-epidermitis or second degree burn, which heals and re-epidermises without leaving a scar. Solomon declares that this phenomenon always occurs when the dose of 4000 R is employed as measured by his standardized iontoquantimeter.

In view of the possibility of variance in the dosage between the French and the German erythema dose, I prepared to test the German erythema dose and to measure it on the Solomon iontoquantimeter. With the co-operation of the makers, I had an

* As measured at the Frankfurt Surgical Roentgen Clinic, Director Prof. V. Schmieden, April, 1924.

iontoquantimeter especially constructed with a conducting rod of three parts, built in the same manner as that of the standard conducting rod of the regular Solomon iontoquantimeter. The apparatus was standardized with one gram of radium. The standardization is explained as follows: The ionization current is measured by timing the rate of fall of the leaf of the electroscope and the value of this current is directly proportional to the amount of energy absorbed by the air in the small chamber.

The ionization result from a gram of radium element in one second, placed at a distance of 20 mm. and screened with 0.5 mm. of platinum is denoted by the letter R. According to Solomon 1000 R units are equivalent to 5 Holzknecht units.

The ionization produced by this gram of radium will cause the leaf to fall through 50 divisions in a certain time. This time expressed in seconds represents the number of R units and corresponds to the total graduations of the scale and is known as the constant K of the particular apparatus. This particular apparatus on measurement had a constant of K = 418.

Through the courtesy of Dr. Hans Holfelder of the surgical clinic of the Frankfurt University I brought the apparatus there and set it up and made the measurements detailed below. The measurements were made of the erythema dosages actually in use for treatment in Dr. Holfelder's service as produced by the following apparatus: The Veifa Neo-Intensive with constant current condensers without kenotrons, and the Siemens and Halske, Stabilivolt, with four condensers and four kenotrons. These apparatus were being operated at the Holfelder Klinik under the following conditions:

The Neo-Intensive: 250 kv., 4. ma. with 40 cm. target distance, with ½ mm. Cu and 1 mm. Al filtration on a field of 6 × 8 cm. giving the erythema dose in 18 minutes.

The Stabilivolt: 200 kv., 7 ma. with 40 cm. target distance, with ½ mm. Cu and 1 mm. Al filtration on a field of 6 × 8 cm., giving the erythema dose in 16½ minutes.

The output of these machines was measured under the above conditions on the Solomon iontoquantimeter. Several readings were made. In the case of the Neo-Intensive apparatus, it was found that the time of fall of the electroscope was 4 min. and 2 seconds. With the Stabilivolt, the time of fall of the electroscope was 3 min. and 50 seconds.

According to Solomon, the formula for the intensity of the radiation or the value of the incident dose is $I = \frac{K}{T}$ where K equals the constant of the iontoquantimeter and T equals the time of fall of the electroscope. The constant K normally and of this iontoquantimeter was calculated on the scale of the apparatus as the electroscopic leaf is timed falling over 50 scale markings. In my tests, I timed the apparatus over 40 scale markings, therefore, in my calculations I used the Constant K = 418 of the apparatus corrected for the electroscopic reading of 40 scale marks giving K = 334.

Calculations. Neo-Intensive: Iontoquantimeter was 4′2″, therefore, $I = \frac{K}{T} = I = \frac{334}{242} = 1.38$ R per second. In 4′2″, the total time or exposure there would be developed 4′2″ or 242″ × 1.38 R or 334 R.

The Stabilivolt: Iontoquantimeter reading was 3′50″ or 23″ therefore, $I = \frac{K}{T} = I = \frac{334}{230} = 1.452$ R per second. In 3′50″ there would be developed 3′50″ or 230″ × 1.452 R or 334 R.

Considering the erythema dose as used in the Clinic, i.e. Neo-Intensive 18′ and the stabilivolt 16′30″ the number of R units produced by these machines respectively would be as follows:

Neo-Intensive, 1.38 R per second as measured above in 18′ or 1080 seconds there would be 1.38 × 1080 = 1490 R. This then would be the erythema dose in use at the Clinic as measured on the Solomon iontoquantimeter and likewise for the stabilivolt: 1.452 R per second × 16′30″ or 990″ = 1437 R. According to Solomon, in his Rapport au Congress de l'A.F.A.S., XIII section, Bordeaux, 1923,

and in a personal communication, the French erythema dose is 4000 R.

Holfelder's erythema dose is that 100 per cent dose on the skin given according to the condition already outlined above, which causes a reddening one week after the treatment and the pigmentation of the skin three weeks afterwards. 110 per cent dose would produce vesiculation. The French erythema dose is a destruction of the epidermis with re-epidermatization in three weeks following the treatment. The French dose is, therefore, of greater intensity than the German dose. Comparing the results from the measurements which I have made the French erythema dose is approximately three times that of the German. Holfelder has been using his dose in one sitting without any appreciable ill effects on the skin whereas the 4000 R dose given at one time on the skin will create a second degree burn, with subsequent restoration to normal.

I wish to express my thanks to Dr. Iser Solomon for his advice in preparing the apparatus and for his assistance in the calculations of the dosage, and also to Dr. H. Holfelder for his courtesy in permitting me the use of the apparatus in his Clinic.

THE EFFECT OF ROENTGEN RAYS ON THE ADRENAL GLAND*

BY CHARLES L. MARTIN, M.D., FRED T. ROGERS, PH.D., AND N. F. FISHER, M.S.

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DALLAS, TEXAS

RADIATION, like other potent therapeutic measures, produces severe reactions in the living organism when large doses are administered. These reactions vary markedly when different regions are radiated. In a previous paper[1] it was shown conclusively that cachexia and death may be produced in dogs by administering heavy doses of roentgen rays to loops of small intestine isolated from the body by lead shields. However, Ivy, McCarthy, and Orndoff[2] state that they have produced the same sort of cachexia in dogs by raying the submaxillary gland area. This observation suggests that cachexia might be produced by administering an overdose to any of the glandular structures.

A recent paper published by Holfelder and Peiper[3] turned our attention to the adrenal gland. These authors claim that adrenal injury results from half the dose that injures the intestine, namely 60 per cent skin unit dose. They feel that all upper abdominal radiation should be administered so that the adrenal glands are fully protected and intimate that ill effects occurring following treatment in this region are secondary to adrenal injury. Lignac and Devois[4] are of the same persuasion but have advanced the theory that changes in the adrenal are secondary to the effect of the rays on the sympathetic nervous system. They not only advise that these glands be protected but feel that adrenalin should be administered in cases of roentgen sickness produced by abdominal radiation. David and Hirsch[5] examined the adrenalin content of the surparenal capsules after applying various percentages of an erythema dose directly to these structures in animals. Most of the glands receiving an erythema dose showed diminished adrenalin production whereas all of those receiving one-fourth erythema dose showed an increased production.

The evidence is not all of an experimental nature. Smithies[6] has recently published a case report which describes a syndrome having all of the characteristics of Addison's disease that appeared following the administration of penetrating roentgen rays in the kidney area. Unfortunately, Smithies did not obtain an autopsy and since there was some question as to the presence of malignancy,

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

the exact cause of the illness was not determined.

Holfelder and Peiper[3] describe 2 cases that showed a generalized bronzing of the skin and a marked lassitude following treatment of the upper abdomen. However, one of these patients had carcinoma of the rectum and the other a carcinoma of the pancreas. It is a well-known fact that metastases in the adrenal glands will produce Addison's syndrome and here again the evidence is not positive.

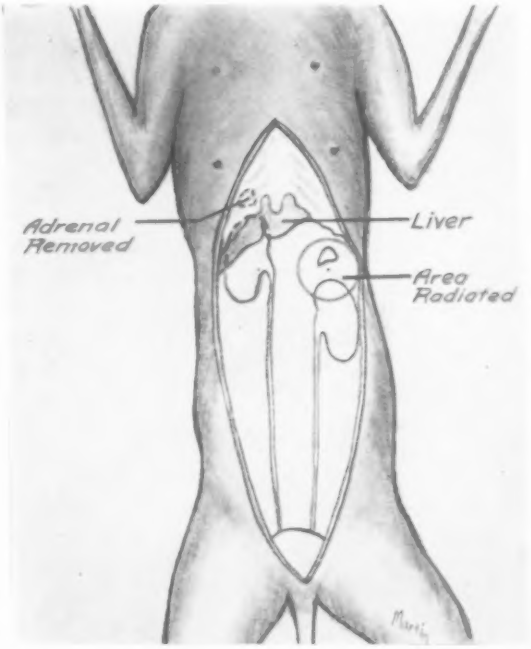

FIG. 1. Diagram illustrating the relative positions of the adrenal glands in a dog. The circle represents the position of the cone.

Tuffier[7] describes a case in which uncontrolled vomiting and grave hematemesis occurred six weeks after radiation of the back. Since these symptoms were arrested in twelve hours by two injections of adrenalin, the author feels that they occurred as a result of adrenal injury.

Arrillaga and Izzo[8] describe a case of Addison's disease. This patient died five days after receiving radiation for carcinoma of the tonsil. The patient went into coma two days after the radiation was given but could be aroused temporarily with doses of epinephrin. The authors conclude that the patient died from adrenal insufficiency brought on by the treatment.

Holfelder and Peiper[3] conducted a series of animal experiments in an effort to establish their theories. Guinea pigs were stretched out on an animal board with the abdomens down and various doses of roentgen rays were administered directly over the adrenal region through a square hole in a protective shield. This opening was 3.5 cm. wide. The radiation given did not cause the hair to fall out but since the erythema dose for a guinea pig's skin is more than three times the erythema dose for the human skin,[9] large doses may have been used. Both reparable and irreparable injuries were produced and some of the animals died. The authors state positively that the intestines showed neither macroscopic nor microscopic changes. In spite of this statement it is our feeling that the ill effects in these animals may have been due to intestinal injuries since we have produced a fatal outcome by raying the abdomen of a guinea pig where it was impossible for us to demonstrate changes in the intestines. Certainly, some of the intestinal tract was included in the field of radiation used by these authors.

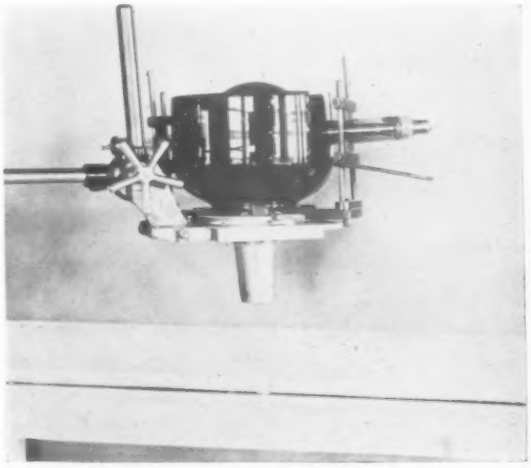

FIG. 2. Special cone made to pass through an abdominal incision and occupy the position indicated in Figure 1.

Since a marked susceptibility of the adrenal would necessitate extreme caution in administering radiation over the upper abdomen it seemed wise to make a study

of the effects of roentgen rays on the isolated adrenal, being careful to shield all other sensitive structures. The dog was selected as our experimental animal but unfortunately, its suprarenal capsules are widely separated. The gland on the right side lies high up under the liver as shown in Figure 1 so that it is almost inaccessible from an anterior incision. However, the left adrenal is considerably lower and may be reached through an abdominal wound. It, therefore, seemed best to first remove the right suprarenal through an incision in the loin thereby making all the remaining adrenal tissue accessible for radiation. Abelous and Langlois[10] showed many years ago that the removal of one suprarenal capsule from certain animals caused no symptoms, whereas the removal of the remaining gland caused death. Such phenomena occur in the guinea pig, cat, and dog and the dog is, therefore, a suitable animal for the present investigation.

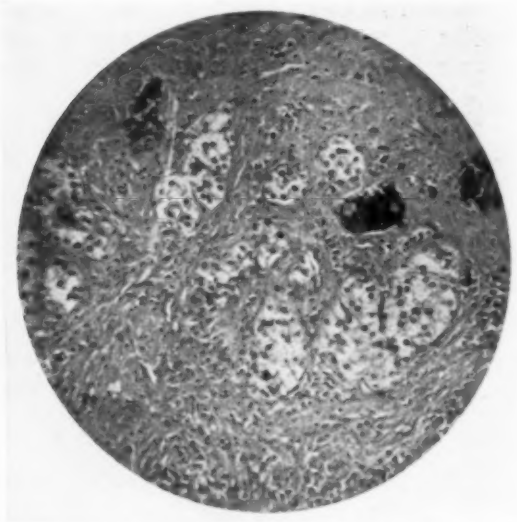

FIG. 3. A microscopic section showing the changes produced by radiation in the adrenal gland. The lighter areas represent islands of cells from the adrenal cortex which have been completely surrounded by dense fibrous tissue. The very dark areas represent calcification.

Four large dogs were selected and operated upon in the manner just described. None of the animals showed any ill effects from this preliminary procedure.

When the wound had healed, a second operation was done on each animal in succession. An incision was made in the upper left abdomen under ether anesthesia and special retractors were inserted to hold the intestines and stomach away from the adrenal. These retractors were fashioned out of wire and covered with moist sterile gauze. Considerable difficulty was experienced in divising efficient instruments. The adrenal lies several inches below the anterior abdominal wall and the success of this experiment depended upon the complete absence of gastrointestinal structures from the field of radiation. After the retractors were placed a tube stand was swung over the operating table. This stand was fitted with a specially devised cone which had been sterilized in an autoclave. The arrangement is shown in Figure 2. The lower end of the cone measured 2 in. in diameter. The cone was slowly lowered through the incision into the abdomen until the lower end encircled the adrenal and upper pole of the kidney as shown in Figure 1. The position of the cone could be accurately judged by looking down through it from above. It was pressed down firmly against the muscles of the back and clamped in position. A dose of 75 ma-min. was then administered at a 5 in. gap and a 10 in. target distance with 10 ma. No filter was used. This dose is one which produces marked cachexia and death when applied to an isolated loop of intestine. For practical purposes it seems unnecessary to study the effects of larger doses. The exposed area was carefully observed before removing the tube stand to make certain that no intestinal loops had slipped under the end of the cone. The incision was then closed.

One animal died from peritonitis four days after the second operation. The other three dogs were placed in an outdoor pen for observation and fed freely.

Dog No. 4 was operated upon and radiated thirteen days after the removal of the right adrenal gland. At the time of the second operation the animal weighed 34 pounds and appeared to be in good condition. It made a rapid recovery and was taking food freely within a few days. No untoward symptoms of any sort appeared. At the end of twenty-six days the animal weighed 40 pounds, having

gained 6 pounds in less than a month. An autopsy done at this time showed the left adrenal gland almost white in color and somewhat shrunken. It had a firm consistency and suggested a lymph node rather than the adrenal. The upper pole of the left kidney showed no gross abnormality although the cortex in the radiated area was somewhat paler than the rest of the kidney.

Microscopic study of the adrenal reveals an extensive replacement of the normal structures with fibrous tissue. In certain areas there are many endothelial cells and fibroblasts whereas in others there are dense masses of collagen fibrils with relatively few nucleated cells. Small islands of relatively normal adrenal cortex are seen scattered through the dense scar tissue. However, no structure that is at all suggestive of medulla is in evidence. A number of small calcium deposits can be seen. It seems strange that such extensive damage should cause no change in the general condition of the animal. Figure 3 illustrates some of the microscopic changes.

FIG. 4. Dog No. 3 as it appeared a few days after radiation of the adrenal area.

Dog No. 3 was subjected to the same procedure as that just described for Dog No. 4 except that nineteen days elapsed between the first and second operations. At the time of the second operation the animal weighed 32 pounds. It made an uneventful recovery and remained in excellent condition throughout the experiment which was brought to a close seventy-eight days after the radiation was done. At that time the dog weighed 39 pounds, having gained 7 pounds in approximately two and one-half months. It was very active and even succeeded in jumping over the six foot fence of the animal pen. Unfortunately, unforseen circumstances prevented our obtaining autopsy material from dog No. 3 and this renders our results most incomplete. Figures 4 and 5 show that no ill effects were produced.

FIG. 5. Dog No. 3 as it appeared 78 days after radiation.

Dog No. 1 was subjected to the routine procedure except that twelve days elapsed between the two operations. The experiment was continued for ninety-eight days following the radiation and the animal gained 11 pounds during that time. An autopsy was done on the ninety-eighth day which revealed a normal left adrenal.

The upper pole of the left kidney showed a greyish area with a rounded border which suggested the limiting edge of the cone. There were also a few grey areas in the peritoneum which suggested roentgen-ray reaction. Histological sections of the adrenal gland showed no definite abnormality. However, sections of the upper pole of the kidney showed a marked proliferation of connective tissue between the tubules and glomeruli. These changes are illustrated in Figure 6. The excessive connective tissue has caused a shrinkage of the kidney substance so that there are

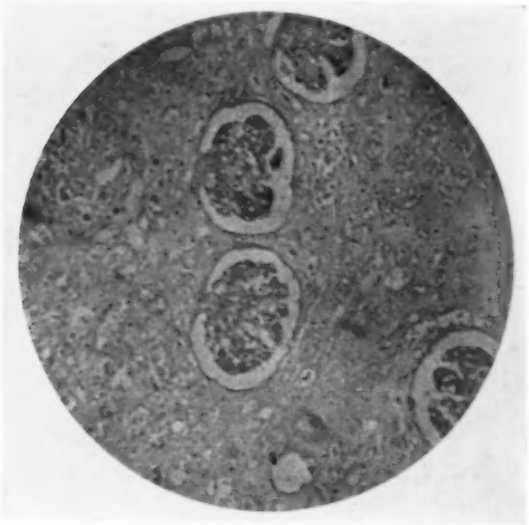

FIG. 6. Section from kidney which received the unit dose of radiation. The glomeruli are surrounded by dense fibrous tissue and the tubules are crowded out of the field.

many more glomeruli in a microscopic field than are seen in the normal kidney. The presence of a reaction in the kidney and no definite reaction in the adrenal suggests that the latter structure must have slipped outside the field of radiation. Dog No. 1 should, therefore, not be considered in the adrenal experiments. It is included in this report to bring out the striking changes in the kidney which suggest an interstitial nephritis.

The incompleteness of our work makes it necessary for us to present this paper merely as a preliminary report. We hope to repeat the experiments allowing the animals with radiated adrenals to be observed over longer periods of time, thereby obtaining some more conclusive evidence bearing on the effects of radiation on the suprarenal capsules. It is our feeling that many of the ill effects attributed to adrenal injury really have some other explanation. This impression is strengthened by a communication from Ewing in which he states that Bagg has produced extensive destruction in the adrenals of dogs with implanted radium needles without producing untoward symptoms.

The work of Lacassagne and Samssonow[11] seems to point in the same direction. These workers implanted both filtered and unfiltered radium needles in the adrenals of rabbits at operation. It was their observation that where extensive necrosis was produced with the bare tubes the animals died in from seventeen to thirty-five days. However, when filtered rays were employed no ill effects occurred so long as even a narrow rim or cortical tissue remained intact. All of their animals showed complete destruction of the adrenal medulla. In our experiments it would seem that some of the cortex remained uninjured.

There may be some criticism of the roentgen-ray dosage used in these experiments, but if it can be shown that a dose that destroys intestinal mucosa does not produce serious symptoms when applied to the adrenals, we feel that the protection of these glands will play a minor roll in deep therapy.

We wish to thank Dr. George T. Caldwell for his kindness in preparing the pathological material used in this paper.

SUMMARY

1. Direct heavy radiation of the isolated left adrenal administered following the removal of the right adrenal of a dog produced no symptoms during practically a month of observation, although a marked fibrosis occurred in the radiated gland.

2. The same dose produced cachexia and death when applied to an isolated loop of small intestine, and marked fibrosis when applied to the upper pole of the kidney.

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DISCUSSION

Dr. Ralph E. Herendeen, New York City. I am sure this paper will help all of us to overcome some of the confusion which resulted from reading reports in the literature recently of damage done to the adrenals from radiating the abdomen or the back. There are cases reported in the literature of very grave results and in some cases death attributed to the radiation of the suprarenals.

In the Journal of the Academy of Medicine of Paris, just recently, Tuffier reported 3 cases, I believe, one of which died as a result of radiation over the upper abdomen to a rather intense degree, which he claimed was due to the effect on the adrenals. Holfelder's work, however, is perhaps more interesting in view of the fact that it was a clinical experiment which was rather accurately controlled. His animals were all radiated in the same way and autopsied and sections studied microscopically, and they found that the clinical course after radiation and the microscopical appearance did not agree at all with the dose given; that is, the damage done to the adrenals in the case of a small dose was duplicated perhaps by a dose three times as large, and in another case a dose, we will say of 100 per cent was necessary to obtain an effect produced in another animal where 30 per cent of that dose was given. So that this experiment it seems to me helps us in the belief that many of the observations reported clinically have not been borne out by actual experimentation.

TREATMENT OF CARCINOMA OF THE ESOPHAGUS BY RADIATION*

BY D. CROSBY GREENE, M.D.

BOSTON, MASSACHUSETTS

THE treatment of carcinoma of the esophagus is up to the present time one of the most disappointing problems in the field of surgery and radiation. On the one hand, we have an almost 100 per cent mortality from attempts at radical cure by operation. One the other hand, as far as I am aware there is no authentic case of cure by radiation. As far as results go the advantage up to the present lies on the side of radiation, since we have by this measure brought about prolongation of life and mitigation of symptoms in a considerable number of cases. Whether the prolongation of life would have been as great had the nutrition been maintained by early gastrostomy without radiation may be open to question. The fact remains that many cases which have reached the stage of obstruction permitting only the ingestion of liquids have shown marked improvement for a time under radiation without gastrostomy. The paper presented by Douglas Quick before the Eastern Section of this society last January, covers very completely the present status of the therapy of this disease. From our limited experience in a smaller series of cases we are in substantial agreement with his conclusions, namely:

(1) That carcinoma of the esophagus is a disease in which we can hope for palliative relief only.

(2) An early gastrostomy offers the major portion of this relief.

(3) External radiation, preferably with high voltage roentgen rays, aids in slowing up the tumor growth, but so far has not controlled it.

(4) Intra-esophageal application of radium, preferably in small repeated doses is indicated to control ulceration and bleed-

* Read at the Twenty-fifth Annual Meeting, American Roentgen Ray Society, Swampscott, Mass., Sept. 3–6, 1924.

ing but has little influence on the actual progress of the disease.

In this paper I propose to report our observations and treatment with special reference to a series of 17 cases at the Massachusetts General Hospital during the past year beginning September 1, 1923.

Our method of procedure is as follows:

The preliminary diagnosis is made by the history and by means of roentgenoscopy and roentgenograms which indicate the location and, to some degree, the extent of the growth. Esophagoscopy is then done, usually under ether anesthesia. The appearance and characteristics of the lesion are noted, a small specimen removed for microscopic examination and the permeability of the stricture to bougienage observed without any attempt at forcible dilatation. If the lesion shows the gross appearance of carcinoma, radium emanation seeds are inserted into the growth under direct vision. In our hands, this method of intra-esophageal radiation, while it has not cured any cases, has been the most effective and satisfactory. In cases where the growth is situated just above the introitus of the esophagus in the hypopharynx occasional apparent cures have resulted from this method. I have in mind one rather striking case of squamous cell carcinoma, a tumor arising from the right lateral wall of the hypopharynx, the size of a small walnut projecting across the opening of the esophagus, in which the tumor has disappeared and has shown no sign of recurrence for three years after treatment by seed insertions. When the tumor is situated within the esophagus its inaccessibility is a great handicap to the effectiveness of this method. With the aid of the esophagoscope the upper portion of the growth can be observed but it is usually impossible to determine the limits of its extension in other directions. The most that we hope to accomplish is the destruction of that part of the tumor which lies within and close to the esophageal lumen and we rely on high voltage roentgen rays for treatment of the rest.

The insertion of seeds into the esophagus is justly regarded as a hazardous procedure. As Quick observes, the esophagus is a thin-walled organ in close relation with many important structures, notably the aorta and left primary bronchus, a perforation into which is disastrous. I have seen at autopsy a case in which death from hemorrhage from the aorta was the direct result of a perforating ulcer caused by radium seed insertions into a carcinoma of the esophagus. This occurred three years ago at a time when we were using seeds of from 3 to 5 mc. strength. With improved technique and the use of 1 mc. seeds we have had no such unfortunate accidents in the past two years. We prefer to employ ether anesthesia for this procedure because it enables us to exercise greater deliberation and accuracy in the insertions. The trocar used is provided with an oval shaped guard at one centimeter from the point, to assist in gauging the depth of insertion. With this instrument four to six seeds are inserted into the presenting portion of the growth, the insertions being made in the direction of the axis of the lumen not more than one centimeter in depth. The immediate reaction to this instrumentation and treatment, if carried out with care and avoidance of trauma, is slight and the patients are usually able to leave the hospital on the following day. Within a few days a decided improvement in swallowing is usually noted, which is doubtless to be attributed to the bougienage.

The deep roentgen treatments have in most cases been given in a series of three or four exposures, extending over a period of about a week beginning a few days after the radium treatment. This part of the treatment has been conducted under the direction of Dr. Holmes. In about eight weeks the roentgen treatment is repeated. At irregular intervals of about two months the direct examination of the esophagus and radium treatment has also been repeated, but our impression is that the most effective radium treatment has been the first one and of late we have relied on the deep roentgen therapy after the initial treatment. The patients report to the clinic for observation at monthly intervals.

Results. Our results have thus far been only palliative, but the improvement in many of the cases has been prolonged for

several months. The first case treated under the general scheme described, a woman, aged forty-two, showed a remarkable temporary improvement after the first radium and deep roentgen treatments. In two months she had gained her lost weight, about 20 pounds, and from being able to take only liquids with difficulty was eating all kinds of solid food with very little trouble. There was also a return of normal vigor which was quite striking. After two months, however, the obstruction became more pronounced in spite of further radiation, with accompanying loss of weight and strength, and she died of inanition four and a half months after the beginning of treatment. Other cases have shown less pronounced but more prolonged improvement extending over periods of from five months to one and a half years.

The changes observed at esophagoscopic examinations subsequent to treatment have varied greatly in different cases. In some a marked regression of the tumor tissue has been demonstrable. In others the swelling incident to the radium reaction has more or less obscured the growth. This swelling may be enough to increase the obstruction to the extent of requiring gastrostomy if this has not already been done.

Of the 17 cases treated at the hospital during the past year, 9 have died or been untraced, 8 are at present under observation.

In our experience death is in many cases not directly traceable to the local lesion nor to extension to other parts. This was illustrated in one of the cases which came to autopsy. The patient, who had been under treatment for eight months, during which time he had been given four radium insertions, was able to take liquids up to the last but gradually weakened and died. The autopsy showed that the greater part of the tumor had been destroyed. At the site of the lesion was an ulceration around the periphery of which cancer cells were found but no tumor. A few small neighboring lymph nodes also showed carcinoma cells.

In other cases we have seen undoubted regression of the growth without improvement in local or general symptoms. Another observation has been that the ability to swallow food does not correspond with the degree of permeability to the bougie. Certain patients with very tight strictures can swallow better than others with more permeable strictures, and sometimes a patient in whom the passage can be demonstrated to have become larger as the result of destruction of tumor tissue will have increasing difficulty in swallowing. It is evident that the muscular mechanism of deglutition in these cases is interfered with by the presence of the growth in the walls of the esophagus. In other cases, where the destroyed tumor tissue has become replaced by fibrous scar tissue, a contraction of the lumen is to be expected. But whether there is actually complete obstruction or not, the patients gradually lose weight and strength and die. This brings up the question of keeping up the nourishment by gastrostomy and direct introduction of food into the stomach. It has seemed to me until recently that as long as a patient was able to swallow liquids or semi-solid food without great difficulty, there was nothing to be gained in having a gastrostomy done, and it was my custom to wait until it was impossible for the patient to swallow liquids before advising a direct surgical opening into the stomach. It was not until last winter, when I heard Chevalier Jackson demonstrate the advantage of early gastrostomy in cases of lye stricture that the possible great advantage which might accrue from this operation in cases of carcinomatous stricture appealed to me. As Jackson has pointed out, a patient with a partial stricture of the esophagus suffers not merely from difficulty in swallowing. Even in the case of partial strictures we often find on esophagoscopy a considerable retention of foul, stagnating material, fluid and semi-solid detritus, whose presence tends to keep up a chronic esophagitis. The absorption of the products of decomposition in itself is undoubtedly harmful, to say nothing of the distaste for food engendered by the disagreeable taste of the foul eructations of gas. This phase of the situation was particularly impressed upon me in 2 cases which I was able to

follow up rather more closely than usual. In both of these cases the swallowing of liquids was maintained with but slight difficulty up to the end and yet they both wasted away and died apparently of inanition. Both declared an absolute distaste for any food, had to force themselves to take it and finally refused to make the effort. In one of these cases esophagoscopy and bougienage done only a few weeks before death showed the esophagus more permeable than it had been two months before.

Although the operation of gastrostomy is relatively serious and productive of little benefit when practiced as a last resort in late cases, it is comparatively safe and results in marked improvement in general condition and in maintenance of bodily weight and strength when done in early cases. It is now my practice to recommend this operation a soon as the diagnosis is made and to forbid the taking of any food by mouth. With rest and cleanliness of the esophagus thus induced, and the nutrition maintained, it seems reasonable to expect more favorable results from radiation than we have yet been able to obtain.

In conclusion, I wish to emphasize the feasibility of radium insertions in this region. Notwithstanding the obvious risks, the method may be practiced with comparative safety by one who has acquired the requisite skill in esophagoscopy and technique of insertions.

EFFECT ON TUMORS OF RADIATION OF DIFFERENT WAVE LENGTHS*

BY FRANCIS CARTER WOOD, M.D.

NEW YORK CITY

WHETHER different wave lengths of the roentgen ray have different lethal effects on tumor cells is one of the important questions in radiotherapy which is yet unsolved. Regaud and Nogier thought that they could demonstrate differences between the effect of hard and soft rays. Ritter, Rost and Krüger found that the difference between the epilation and the erythema dose was increased with the hard rays. Holthusen, also, believes that there is a difference in effect.

The most recent study of the question has been made by Russ. He thinks that "About six times as much short wave-length energy as long wave-length energy must be expended in a layer of skin, in order to produce equal reactions, and that this factor falls to about 2.6 in the case of a tumor." He used a rat tumor, whether carcinoma or sarcoma is not stated. About 300 animals were used in the experiment.

Russ's paper is not very clear and the fact that he used for his long wave lengths unfiltered radiation at approximately 100 kv., and says that the wave lengths would range from 0.45 to 0.30 Ångström units, complicates the whole situation, as the longer wave lengths would be very largely absorbed in even a thin layer of tissue and hence produce a very great effect. The hard rays were produced at 210 kv. and filtered by 1 mm. of aluminum. He estimates that the wave length so passed is about 0.168 Ångström units which is probably only a very rough approximation. Under these conditions equal ionization doses were given. He used five varieties of ionization chambers, one an open one 1 × 0.4 × 2 cm., the others were made of wood, aluminum and paper.

He notes that they did not give identical readings. Whether the rays in the open chamber passed through 1 or 2 cm. of air was not stated.

Most physicists have assumed that the only factor in the destruction of tissues is the amount of roentgen-ray energy absorbed and that an open ionization chamber of considerable length avoids many of the complications of the closed chambers. There is however no general agreement as to the dimensions necessary for the best results.

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

Krönig and Friedrich, as contrasted with Russ and the other authors cited, found that in using aluminum ionization chambers considerable differences existed between the action of long and short wave lengths. They used tadpoles. But when they employed a graphite chamber, free from metallic substances, they found no difference between unfiltered rays and those filtered with 1 mm. of copper, and also none between gamma rays of mesothorium and radium isolated by filtration through 1½ mm. brass and 5 mm. celluloid, and roentgen rays filtered through 1 mm. copper.

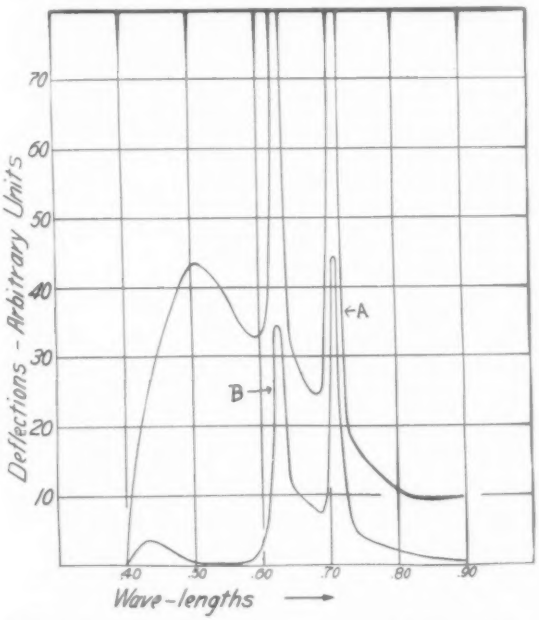

FIG. 1. Spectrometer curves from a molybdenum tube running at 31 kilovolts continuous current and filtered by 0.065 millimeter molybdenum. A. Unfiltered radiation. B. Filtered radiation. The filtered spectrum shows that the wave lengths are approximately 0.62 to 0.73 Angström.

Krönig and Friedrich's voltage for short wave lengths is stated only as 40 cm. between a point and plate spark gap. The exact voltage, therefore, is somewhat in doubt.

Krönig and Friedrich's results have been criticized by Holthusen and others, the statement being made that the similarity in effect between the various groups of radiation is merely an accidental one and not necessarily a true finding.

The writer showed some time ago that, when using a standard animal tumor, the same number of human skin erythemas were required to kill all the cells whether unfiltered, filtered, or radium gamma rays were used, but the variability of an erythema on human skin makes this determination of little scientific value whatever its practical importance may be. The writer, therefore, began a series of experiments to attempt to solve the problem.

In the first place, the measurement of the exact output of roentgen rays from machines delivering a pulsating or alternating current is difficult, and gross errors are possible. The current used, therefore, was a continuous one, generated by a machine of the type developed by Hull and Duane. The voltage was measured by shunting the high voltage circuit through a 20 megohm resistance made of fine wire wound on porcelain and baked in the glaze, the whole being immersed in transformer oil. The current passing through was measured by an accurately checked Weston milliammeter. This was kept continuously in the circuit so that any alteration in the voltage could instantly be observed, but the apparatus showed prac-

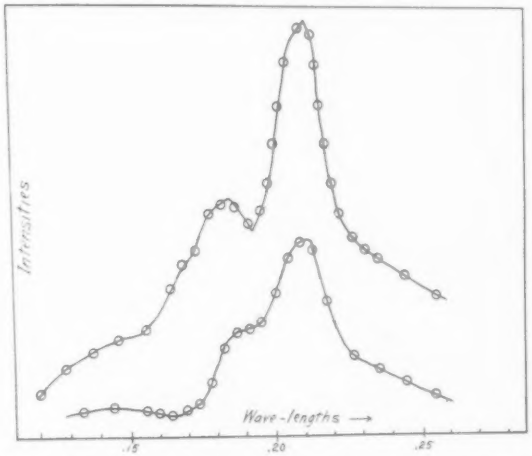

FIG. 2. Spectrometer curves from a tungsten Coolidge tube running at 100 kilovolts continuous current with tantalum filter of a thickness of 0.125 millimeter. The upper curve is the unfiltered, the lower curve is the filtered radiation. The tracing shows that the wave lengths are roughly comprised between 0.20 and 0.23 Angström.

tically no fluctuation in the voltage delivered at the terminals when it was properly adjusted. Four kenotrons were used, giving full wave rectification, and large capacity condensers in the circuit assured constant potential. The milliamperes through the tube were read with a highly accurate Weston milliammeter and the filament heating current with a similar ammeter. During some parts of the experiment the current was supplied by storage batteries, and during others by a transformer in

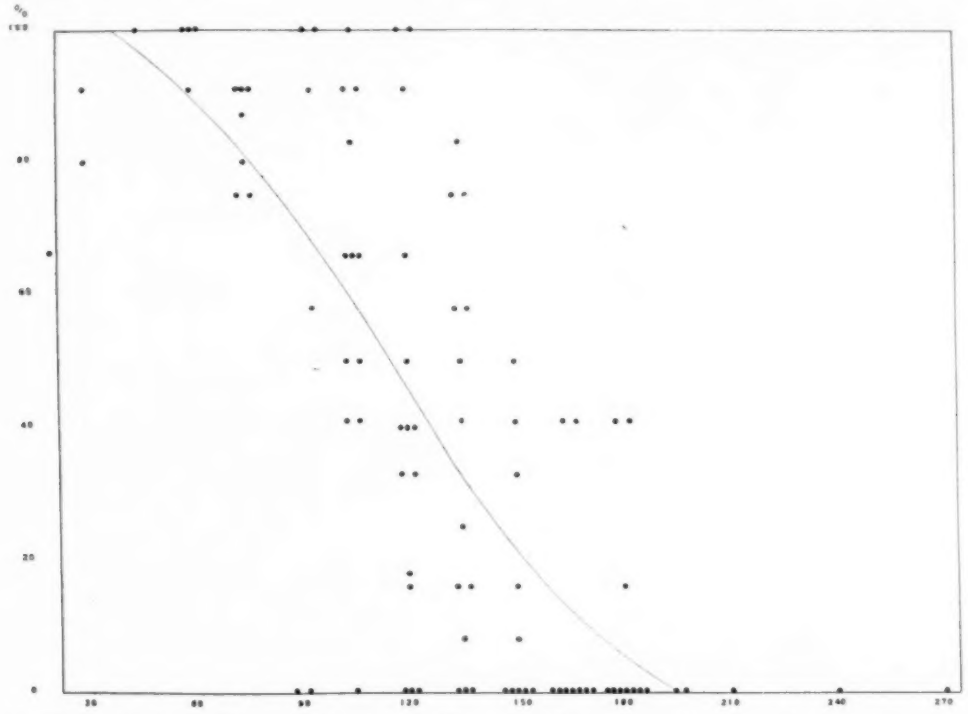

FIG. 3. Chart showing 1188 inoculations of the Flexner-Jobling rat carcinoma; each dot representing 12 inoculated animals. The tube used was of the Coolidge type with molybdenum anticathode. The filtration was with 0.065 millimeter of molybdenum. The tube was running at 31 kilovolts, 30 milliamperes, and the distance between the anticathode and the tumor itself was 40 centimeters. No tumors grew after an exposure of 180 minutes.

combination with a Rieber stabilizer. By either method, the current could be controlled within 1 per cent.

The hourly fluctuations in the output were probably not over 1 or 2 per cent. Measurements of the output of the tube were made with an open ionization chamber of the Duane model somewhat modified from the original having a 15 cm. column of air. The most important of the modifications consisted in placing at either end of the ionization chamber a heavy lead collar extending about 17 cm. above and below the openings of the chamber. The purpose of this was to prevent scattered radiation from any portion of the apparatus entering the chamber.

The tube was inclosed in a large box covered with 6 mm. of lead. Water cooled tubes were used, one with a molybdenum anticathode and the other with a tungsten anticathode. Both were made by the General Electric Company, and I wish to thank Dr. Coolidge for his kindness in lending me a new water cooled tungsten tube for part of the experimental work.

It was found with the voltage used that satisfactory cooling could be obtained by running water from the city mains through about 100 feet of rubber tubing as an insulator. The leak at 100,000 volts under these circumstances was very little, somewhat less than the leak through a 20 megohm resistance, so that the complication of pumps and radiators was avoided.

In order to obtain a limited beam of which the average wave length could be determined with some accuracy, filters were used of sheet molybdenum and tantalum, the first 0.06 mm., the second 0.125 mm. in thickness. Zircon filters such as were used by Hull in his powder work were not used as the presence of the beta line added a good deal of energy and shortened exposures. The secondary radiation from the filters having approximately the same wave length as the radiation transmitted by them, supplementary filters of aluminum were not used. The distance from the anticathode to the material was 40 cm.

The tissues were cut into small particles averaging less than a millimeter in diameter and were sealed in thin celluloid tubes and the whole supported on a thin sheet of celluloid so that all scattering was reduced to a minimum. The tumor particles were exposed to a beam of roentgen ray containing practically only the alpha and beta K lines as shown in the charts.

These spectrometer determinations were made by Dr. H. M. Terrill in my laboratory, using the filters which were employed, and a 130 cm. ionization chamber filled with methyl iodide, giving very complete absorption.

The Duane ionization chamber was arranged so that its openings were at the same level as the tumor tissue, and the material after it was placed in position could be replaced by the ionization chamber for checking without disturbing any portion of the apparatus. The chamber carried a couple of lugs which rested on horizontal bars and the tumor and its celluloid support slid along the same bars. Repeated checks were made of the ionization dosage.

The first exposures were made with the molybdenum tube and molybdenum filter,

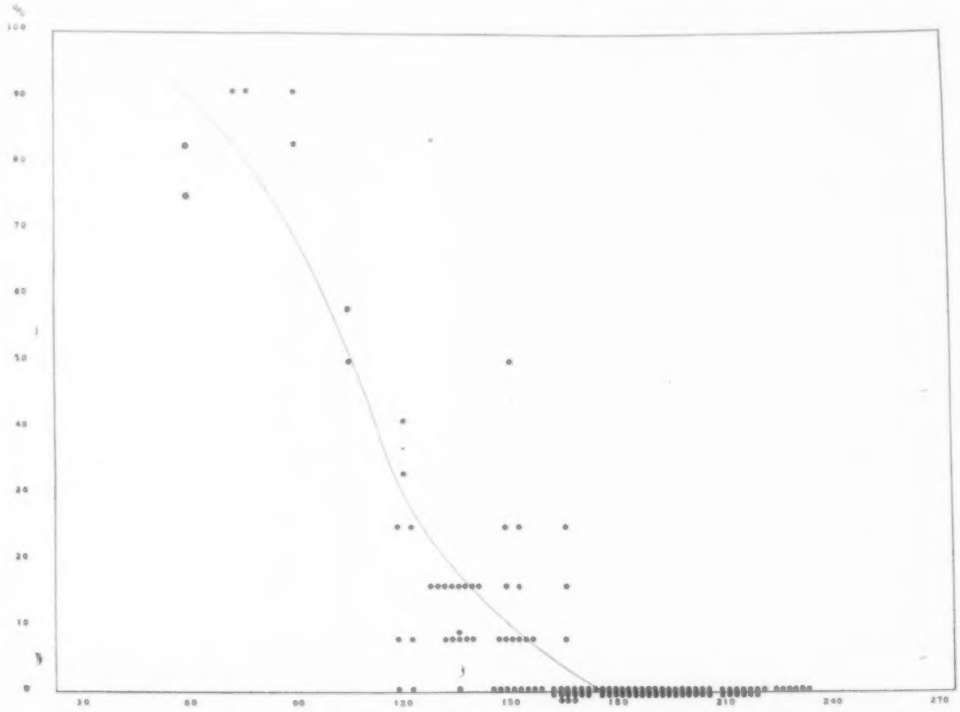

FIG. 4. Chart showing 1464 inoculations of the Flexner-Jobling rat carcinoma, each dot representing 12 inoculated animals exposed under exactly similar conditions as those in Figure 3, with the exception that the Coolidge tube had a tungsten anticathode and was run at 100 kilovolts with a continuous current of 12 milliamperes and a tantalum filter of 0.125 millimeters. The distance from the anticathode to the tumor was 40 centimeters. The curve shows a slightly different shape from that in Figure 3, but the number of observations is smaller. It will be seen that no tumor cells grew after 195 minutes' exposure as compared to 180 minutes in Figure 3—a difference of about 8 per cent. This difference is not significant.

using a variety of animal tumors, including mouse tumor No. 180, which has been used in this laboratory for radiation tests for the past ten years and the Flexner-Jobling rat carcinoma and rat sarcoma No. 10.

The currents through the ionization chamber were measured by a Leeds and Northrup galvanometer of high sensitivity especially made for the purpose.

The molybdenum tube was adjusted to give what was considered the maximum amount which it could deliver. Measurements were then made with the ionization chamber and the deflections noted.

After a run on tumor tissue the tubes were shifted, the tungsten tube inserted and the deflections on the galvanometer adjusted to exactly the same point as with the molybdenum tube by varying the filament current until the two tubes were delivering equal quantities of roentgen rays as measured by the open ionization chamber at 15 cm. in length.

The voltages selected were 30,000 and 100,000. The first gave an optimum yield of the characteristic K radiation from molybdenum and the second the optimum from the tungsten with a minimum of short general radiation. The tungsten wave length was approximately 0.2 of an Ångström. The raising of the voltage to 200,000 would result in shortening the average wave length only 0.03, so that the conditions realized offered a range of wave lengths fairly within the limits of our present practical application of roentgen radiation, for if the voltage were increased from 100,000 to 200,000 the chief effective output is in the increased energy from the characteristic lines, the shorter side presumably giving but little biologically effective energy.

In order to obtain a limited wave length shorter than the tungsten it would be necessary for the tube makers to develop a tube with an uranium anticathode, using

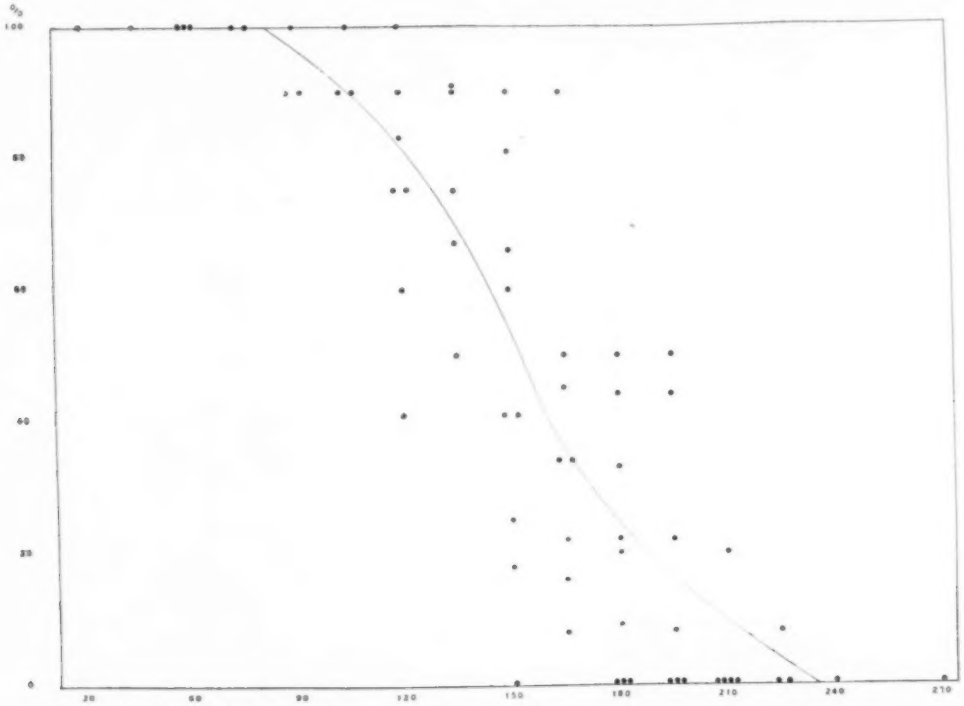

FIG. 5. Chart showing 828 inoculations of Crocker Fund tumor No. 180, each dot representing 12 inoculated animals. The conditions of exposure were a continuous current exciting a Coolidge tube with a molybdenum anticathode, 30 milliamperes passed through the tube at 30 kilovolts. The distance of the tumor from the anticathode was 40 centimeters, a molybdenum filter of 0.065 millimeters was used. No tumors grew after an exposure of 240 minutes as contrasted to the results in Figure 6, where out of 72 tumors one grew. The slight difference between the killing point and that shown in Figure 6 is, of course, negligible.

uranium as a filter. The development of a practical tube of this type depends upon further advances in the metallurgy of uranium and also in tube construction. When such a tube is obtainable it will be of interest to extend these experiments further.

As may be seen from the charts, the killing dose of each type of tumor was practically the same when exposed to these two radiations.

A word in explanation of these diagrams. The ordinate represents percentage of tumor takes, the abscissa the time of exposure to the roentgen ray. They represent the number of surviving tumor particles just as the conventional mortality curve represents human survivals under the conditions of exposure to disease, the number growing smaller as the exposure is prolonged.

In order to show the method of construction the tables are plotted with dots, each representing twelve animals, the unit number kept in each animal cage. Each of these animals has been inoculated with a tumor particle after the latter has been exposed to the roentgen ray. Some grow, some do not. The percentage surviving is computed and a dot is placed in the proper column corresponding to the exposure. The chart looks very irregular, but a general trend is obvious. At first with the increasing dose there is little effect, then there comes a sharp drop and later the rate of fall alters again and becomes less sharp. If the individual observations are added and averaged the combined dots lie nearly on the curves as drawn. If a very large number of animals were used the dots would all be on the curved line. Such an experiment would be, however, very expensive and is quite unnecessary to demonstrate the facts.

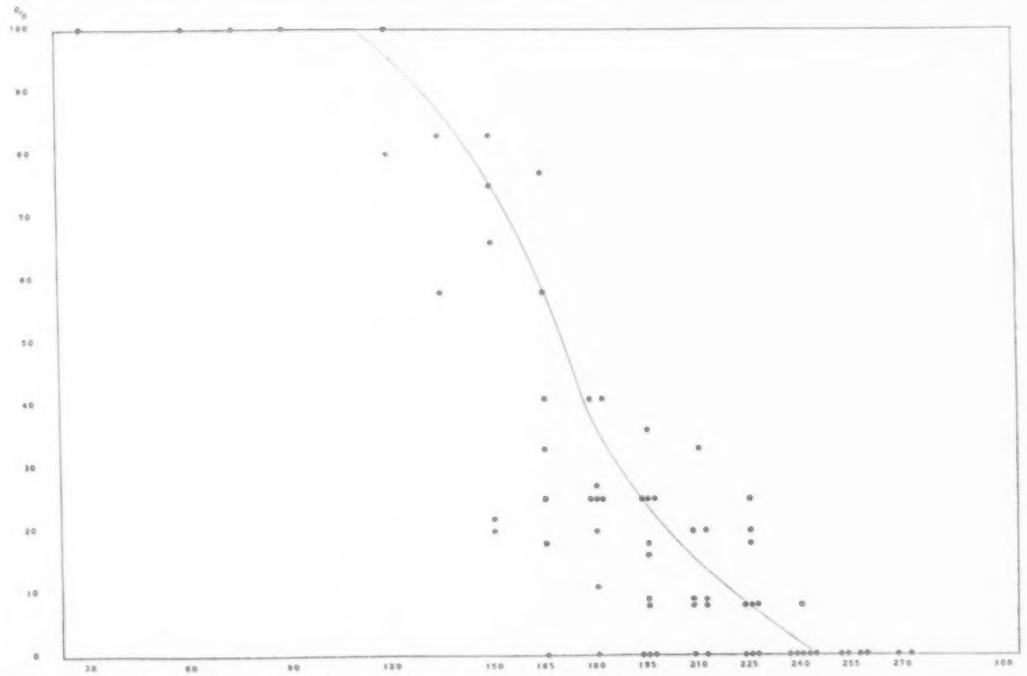

FIG. 6. Chart showing 840 inoculations of Crocker Fund tumor No. 180, each dot representing 12 inoculated animals. A Coolidge tungsten tube was excited by a continuous current at 100 kilovolts, and the distance from the anticathode to the tumor was 40 centimeters. A tantalum filter was used of 0.125 millimeter thickness. Almost all the cells were killed at 240 minutes and all were destroyed at 255 minutes. The charts show that tumor No. 180 is more resistant to roentgen ray than the Flexner-Jobling rat carcinoma. A light erythema is about 50 minutes. hence No. 180 requires 5 erythemas and F. R. C. about 3½ both without scatter.

The reason that the dots are irregularly placed means only that the cells in the tumor particles vary enormously in their susceptibility to radiation. Some, especially those in mitosis, are very sensitive, others

resistant. The survival of the resistant ones means that a tumor will grow when the graft is inoculated. When such an inoculation is done most of the cells in the graft die from lack of nutrition and only a few about the periphery survive. Now it may accidentally occur that all the cells which have been killed by the ray are on the outside of the graft. The inner cells die of starvation and the result is that no tumor will appear. If all the cells in all the grafts were equally sensitive the dots would all be on the same vertical line, but this is quite as unlikely to occur as that 100,000 people of the same age in a large city should all die the same day. Even among cells all derived from a single mother cell, like a brood of the protozoon Paramecium, there will be demonstrable differences, though all are of the same age, grown in the same solution and derived from a single parent. How much less likely are tumor cells to be exactly equally sensitive to radiation. Some are evidently highly resistant for they are not killed by very long exposures.

DISCUSSION

These experiments solve the problem for the effect on animal tumor cells by equal ionization doses, as measured under the conditions specified. Whether such equal ionization doses are equivalent to equal quantities of radiant energy is a question for the physicist. It is probable, however, that such open chambers are far more reliable than the closed type in which the secondary radiation and scattering introduces errors which we have no satisfactory means of estimating. Calibration with an open chamber is the only method at present applicable.

As far as these experiments go, therefore, they point to the fact that within practicable limits of wave lengths there is no difference in the lethal effect on tumor cells of long and short wave-length radiation provided equal quantities are employed, and I think that this is the trend of practical experience.

There also seems to be no great clinical difference in the effect of equal quantities of either gamma radiation, much of which represents a potential difference of 200,000 to 500,000 volts, to the ordinary average wave length as produced by commercial machines which repeated measurements have shown with different apparatus and in different laboratories to be about 0.17 Ångström, and the ordinary low voltages used by dermatologists in the treatment of superficial lesions. The differences in clinical types of skin erythemas produced by different qualities of roentgen rays do not invalidate this statement, for with unfiltered rays the lesion is largely in the upper few millimeters of the skin while the slow destructive lesion produced by highly filtered short wave lengths is several centimeters deep. Obviously the clinical picture will be different. If the wave length is not important biologically then the determination of the proper voltage to be employed in the treatment of tumors is purely one of physics. That is, it is only a question of how short a wave length must be used in order to obtain a satisfactory depth dose, for the depth dose itself is very largely a function of the wave length.

Other practical questions arise. One advantage of high voltage is the greater output of the tube as the potential rises, but with this is coupled the fact that the proportion of scattering is greatly increased. Any one who has seen how easily bones of the hand can be demonstrated in a roentgenoscope at a distance of three or four feet from a patient into whose body a beam of short wave-length roentgen ray is entering, must realize that this extraordinary lateral scattering must cause far-reaching damage in the hematopoietic system of the patient and also possibly in neighboring organs not directly in line with the beam.

These are points which only clinical experience, and a great deal of it, can decide. But we are to-day just beginning to realize the difficulties and complications of our problem. Now that roentgen apparatus is so highly perfected, the clinical results following the selection of wave lengths must be carefully studied and it must be remembered that both clinical experience and animal experimentation has shown that tumors of the same morphology vary greatly in their roentgen-ray susceptibility.

There is much to be done, then, in physics, and still more in the biology of human tumors.

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DISCUSSION

Dr. G. FAILLA, New York City. The question which Dr. Wood discusses in this paper has interested me for a long time, but I have always maintained a neutral position in the controversy because no clear-cut evidence has yet been presented in support of one view or the other. After reading Dr. Wood's paper I still maintain my "neutral position," although I do not question the correctness of the experimental results. There is no doubt that the work was done carefully and that the precision of the lethal dose determinations is as good as can be obtained in pratice. However (as Dr. Wood states, in effect) strictly speaking, the conclusion that the lethal dose is independent of the wave length applies only to the tumors mentioned, the particular set-up employed in the experiments, and the two wave-length ranges used. In order to draw general conclusions much more experimental evidence is required. As far as I am concerned, however, I do not regard the extension of such experiments to human tumors as essential. If we can prove that the wave length of the radiation *per se* plays no significant part in *a number* of biological reactions brought about by radiation, I believe we shall be justified in applying the result to radiation therapy. It may be added that clinical observations are of very little value in the solution of this problem.

Let us examine for a moment the results of Dr. Wood's experiments from a different point of view. The all-important consideration, as far as radiation therapy is concerned, is whether the susceptibility ratio[1] changes with the wave length or not. That is, for example, whether the relative susceptibility of a tumor and of the skin is different when "soft" or "hard" roentgen rays are used. Russ found that there is a considerable difference for a particular rat tumor and the animal's skin, but his experiments are not unequivocal.

Dr. Wood used two different rat tumors, which we may call A and B, and two distinct "qualities" of roentgen radiation, m and n. We may represent the combinations of irradiated tumor by Am, An, Bm, Bn. (I am indicating that tumor A was treated with radiation m, etc.) The doses *just sufficient* to kill all the tumor cells were Am = 195P, An = 180P, Bm = 240P, Bn = 255P; where P may be taken to represent the ionizing power of the radiation as measured by the special instrument used. Within the limits of experimental error Am = An, and Bm = Bn, which means, as pointed out in the paper, that equal "ionization doses" produce equal lethal effects in either tumor. Now the importance of this result does not lie in the fact that there is a correspondence between ionization effect and biological action, for this may be accidental. The important point is that the same relation between physical and biological effects seems to exist for *two different* tumors. The consequence of this result is that the susceptibility ratio between the two types of tissue is independent of the wave length for the two radiation beams employed. If this can be proved to be true in general it will have a far reaching effect in radiation therapy. For this reason it may be well now to examine more carefully Dr. Wood's data.

If we determine the susceptibility ratios of the two tumors we have

$$Rm = \frac{195P}{240P} = 0.81 \text{ for the radiation m and}$$

$$Rn = \frac{180P}{255P} = 0.71 \text{ for the radiation n}$$

Since the latter is of shorter wave length than the radiation m, this result would tend to substantiate Regaud's contention that the more penetrating the radiation is, the more "selective" is its action. However, the difference between the two ratios is within the limits of experimental error, and such a conclusion is unwarranted. In fact, considering the inherent difficulties of such experiments, the difference might be still larger without being significant. I think, however, the results permit the conclusion that *if* there is a difference in the relative susceptibility of these two tumors for radiations of approximately 0.68 and 0.22 Ångström units respectively, it is not greater than about 25 per cent. Still this is a very appreciable *possible* difference, which, if it should exist, could not be overlooked in radiation therapy.

It should be noted that looking at the question from the point of view of the relative

[1] For a definition of this term see "A Brief Analysis of Some Important Factors in the Biological Action of Radiation" read at the Chicago Meeting of THE AMERICAN RADIUM SOCIETY, June, 1924, and which is published in this issue of the Journal.

susceptibility of tissues simplifies considerably the solution of that part of the problem which has the most important bearing in radiation therapy. The susceptibility ratio does not depend on the physical method adopted to measure the radiation. The only requirement is that the same measuring instrument be used when different types of tissue are irradiated with a beam of definite quality. In fact, a different instrument might be used for each quality of radiation employed. In view of this, if Dr. Wood has determined the lethal doses for these two tumors when using gamma rays, I should like very much to know what the susceptibility ratio is. This added information might enable us to draw more definite conclusions from the roentgen experiments.

A discussion of this paper would indeed be incomplete without mentioning the excellence of the practical method employed by Dr. Wood to obtain distinct beams of roentgen rays within a small range of wave lengths. As far as I know this is the first time that such a method has been used for biological experiments, and I wish to congratulate Dr. Wood and Dr. Terrill for having introduced it in this type of work. In conclusion, I wish to point out also that the data given in this paper are far more accurate than any I have seen in connection with this problem.

THE ACTION OF ROENTGEN RAYS ON CORNS*

BY A. HOWARD PIRIE, M.D.

MONTREAL, QUEBEC

THE action of roentgen rays on corns has long been recognized and the only new point I wish to bring out is the action of a large dose. With a suitable large dose the whole corn comes off in one piece, leaving soft healthy skin behind, with no vestige of a corn remaining.

The dose is 4 epilation doses applied in one sitting, using no filter. Expressed in electrical units, the dose in 8 ma., 7-in. gap, 9-in. skin focus distance, 4 min. and 40 sec., with a broad focus universal Coolidge tube. Only the corn and no surrounding skin is exposed to the rays. This is accomplished by covering the foot with a sheet of lead in which is punched a hole just large enough to allow the corn to protrude through it.

Following the treatment some patients experience no unusual sensation; others complain that about three to seven days after the treatment the corn is painful for a few days, others complain that from three days to a week the pain is severe. It is difficult to account for the pain or the want of pain following the treatment. One reason may be that a large corn filters out so much of the rays that the underlying nerve-bearing area gets a smaller dose than when the corn is thin. For this reason I reduce the dose for a thin corn or one that has been cut flat. Another reason for the pain is the wearing of tight shoes after the treatment. No treatment can compete with tight shoes for causing discomfort and if a patient insists on wearing such shoes it is better to refuse roentgen treatment.

After the first few days of pain after the treatment, the corn becomes painless and about a month after the treatment by prying with a finger nail around the edge of the corn a slight separation can be effected and after several days the corn can be separated whole. It can be picked off to pieces before it is ready to come off but the latter is not advisable.

Corns removed by this method have not returned after a lapse of a year and a half. This refers to the first case I treated (February 11, 1923). The later cases have not reported any return of a corn.

The same dose may be given to the sole of the foot as to corns on the little toe, or between the toes. Corns between the toes and soft corns have also been removed by this method.

I have had 21 cases and have treated 26 corns. I have never exposed a large area to the dose and I consider it would be dangerous to do so. Only the corn and nothing beyond it must receive the dose.

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

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Information of interest to all readers will be found on page vii. Lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on page preceding Editorial Section.

A PIONEER IN ROENTGENOLOGY

WHENEVER a new field of science is opened up by some epoch making discovery, there are always a few men having the scientific imagination to realize the far-reaching extent of such a discovery. Pioneers, in exploring new countries or the untravelled domains of science enjoy meeting and overcoming difficulties, both physical and mental. Many countries have had their pioneers in roentgenology. The roentgenologists of England honor Thurston Holland. The French take pleasure in pointing out the achievements of Béclère, and the Germans point out the works of Albers-Schönberg, Holzknecht, Rieder, and many others. In this country we have many names which naturally come to our minds when this topic is suggested. We revere the work of Kassabian, Leonard, Dodd and Caldwell. It is impossible to choose from the many names that crowd themselves upon us those whose work has been the most valuable. It must be left for some writer in the time to come to evaluate the work of many who are still active in the field of roentgenology. Of very great interest at the recent meeting of the American Roentgen Ray Society was the opportunity which the members had of meeting again Dr. Francis H. Williams. The valuable work of Dr. Williams in the early period of roentgen-ray investigation has singled him out as one of the pioneers of American roentgenology, a pioneer whose contributions will always be remembered both from a historical standpoint and also from the fact that the work which he has done constitutes a considerable part of the foundation of our present knowledge and methods.

Dr. Williams, in 1901, published "The Roentgen Rays in Medicine and Surgery." This volume really marks the beginning of American roentgenologic literature. In the opening pages is a half-tone illustration graphically showing the comparative densities as revealed by roentgen rays of many of the substances which go to make up the human tissues. This table of densities was originally published by Dr. Williams in January, 1897, and was republished with the following paragraph:

"This experiment suggests how we may recognize some changes in chemical composition made in the body by pathological processes. The ability to do this without beaker or re-agents, or without disturbing the vital processes is a step in the application of chemistry and physics and practical medicine, which hints that which the future may have in store for us."

The directions given by Dr. Williams nearly a quarter century ago for the examination of the chest are delightfully precise, differing from many later works where too much is taken for granted. I quote the following: "In making examinations the three following stages should

be kept distinctly and separately in mind; first, attention should be given to observing carefully the appearances which present themselves; second, a very careful record should be made of these appearances in some simple and direct way which will be a record of facts, not of opinions; third, the observations made should be well considered by themselves and in connection with information furnished from other sources. The evidence from each source should be given just, but not exclusive consideration for making a diagnosis." It would be hard to find three more useful rules for the examination of patients. Farther on occurs a sentence reprinted from an article published in October, 1896. "I have examined about forty cases of pulmonary tuberculosis and find, not only that the fluoroscope is of value in determining the extent of the disease, but also sometimes in view of its location where and when it would otherwise have been unsuspected." In the chapter "Pulmonary Tuberculosis" illustrated by roentgenograms of post-mortem specimens, and many pulmonary records, there occurs the following sentence: "With the use of the X-ray in connection with other methods of examination, tuberculosis in its early stages will be less frequently overlooked than formerly," and a little further down the page you will read, "I do strongly urge the addition of a careful X-ray examination and I desire to emphasize the value of this method of affording indications of pulmonary tuberculosis in the early stages of the disease." The medical profession, even in the east, however, was not keen to take up this new method of examination. It is related, at an early meeting of a well-known medical society of Boston, that a very famous professor, after viewing the demonstration by Dr. Williams of several roentgen-ray plates, expressed himself as follows: "I cannot see the shadows which have been indicated. I know that you cannot see the shadows which have been spoken of, and I am quite sure, if the truth were told, that the speaker of the evening cannot see all the shadows which he speaks of." These remarks at the time caused much laughter at the expense of the author of the paper of the evening. However, the lapse of a quarter of a century shows that the laughter should rather have been directed against the critics with the unreceptive mind. It is always illuminating to ask such critics of new methods to re-read the preface in the English translation of Laennec's work on auscultation, where the translator concludes his preface with the sentence "that although the stethoscope undoubtedly will prove of great value in the examination of cases in military and naval hospitals, still the spectacle of grave physicians listening to a patient's chest is something so ludicrous that it will prevent its universal adoption in private practice."

Farther on in Dr. Williams' work, occur these words, which I cannot resist quoting. "The conclusion naturally follows that the medical uses of the X-ray should be in the hands of *trained physicians*, and that they must learn to make and interpret their examinations just as they have learned the use of other methods of examination, for instance, auscultation and percussion. All medical schools should teach the method of X-ray examination in connection with auscultation and percussion, even though the student never have the opportunity to use this method itself when he becomes a practitioner, for the use of these examinations will teach the student to interpret better the signs given by the former methods, and to understand their limitations."

From the chapter on examination of the esophagus, abdomen and pelvis I will quote again. "I have not tried all the various methods in use, but have found the one which I have used, namely the mixture of subnitrate of bismuth with food, quite satisfactory. My first observations were made four years ago with this salt, the use of which would naturally suggest itself to anyone who was seeking a substance opaque to the rays and harmless to the patient." Inasmuch as this book was printed in 1901, it establishes the date of the use of the barium meal by Dr. Francis Williams in 1897, and when we recall that Cannon published his article on the movements of the stomach studied by the means of the roentgen ray in May, 1898, it will be obvious that these two American

roentgenologists were indeed pioneers in the use of the opaque meal.

It is interesting to read the chapter on the therapeutic uses of roentgen rays, and to note that in those pioneer days, before filtration, and before methods of measurement were known, good results were obtained at least in the treatment of superficial conditions. The chapters on surgical conditions, namely fractures, dislocations, foreign bodies, bone diseases and so forth, are profusely illustrated, and some of the illustrations compare favorably with those found in books published during the past five years. It is an inspiration to have access to this volume, showing as it does what this pioneer roentgenologist is leaving to posterity.

We could make many more quotations from this and other writings of Dr. Williams to show his accurate knowledge of the roentgen ray in those pioneer days and his clear vision of its future possibilities in medicine. Roentgenology owes him a real debt which it gratefully acknowledges. He is still an active thinker and worker as was shown by his contributions at the recent meeting of the American Roentgen Ray Society. We wish him *bon voyage* for all the remainder of his journey.

P. M. Hickey.

IRA SIMMS 1878–1924

The sudden death on August 29, 1924, of Mr. Ira Simms of New York, has deprived the science of roentgenology of a devoted and faithful pioneer.

Mr. Simms was born in Washington D. C. on December 31, 1878. He began work in the Roentgen Laboratory of Roosevelt Hospital, N. Y. in 1900, later becoming associated with St. Luke's, Presbyterian and for a short time with the French Hospital, visiting each one during the day. From 1907 to 1917 he was on full time with the Presbyterian Hospital.

In the summer of 1917 he became associated with Dr. F. M. Law of New York taking care of work in the office and at the Manhattan Eye, Ear and Throat Hospital as well as the Woman's and the Knickerbocker Hospitals. Press of work necessitated his giving up the Woman's Hospital but the other positions were retained until his death.

He lost the terminal phalanx of the first finger of the left hand in 1907 as the result of the action of the ray, and subsequently numerous skin grafts were done on the hands. In February, 1924, there was an amputation of the stump of the first finger of the left hand as well as removal of the axillary glands on that side. The stump proved to be epitheliomatous but the glands were clear. He suffered from a severe phlebitis following the operation which persisted with decreasing severity until his death. On August 10 he was taken with a severe attack of what was supposed to be acute indigestion lasting three days, this was followed in a few days by an aphasia which promptly cleared up. Ten days later while feeling fairly well he died suddenly from a thrombus of the coronary artery, the culmination no doubt of the extensive burns received in the early days.

Although Mr. Simms did not have a medical degree he possessed a knowledge of roentgen diagnosis that made him an invaluable aid He was a tireless worker and was completely wrapped up in his work, giving an attention to details which made him an ideal technician. He possessed a sense of humor which masked the severe and continuous pain he suffered. He had a personality which endeared him to all with whom he came in contact. He was a "man worth while" and a martyr to the art he loved.

He is survived by his wife, mother and one brother.

F. M. Law.

OUR OWN PROPAGANDA FOR REFORM

A casual study of the growth of the science and art of roentgenology will impress the student with the fact that our specialty, in the course of its development and progress, has run the gamut of trials and tribulations of Mother Medicine itself. From the day that Ea, the Lord of Deep Wisdom and healer of the sick, arose from the sea and instructed the people in learning, down through the days of Harvey,

Jenner, Lister, Pasteur, Koch and our present militant American Medical Association, progress has ever been obstructed by the reactionary, and the fruits of scientific achievement appropriated by the charlatan.

Roentgenology has survived all the storms that its ancient and modern predecessors have weathered. Literally has it risen in a quarter of a century from the humble corner next to the coal bin in the cellar to the magnificent wing that has just been added to "our hospital."

From the days of the pugnacious Galen to those of the patient Pasteur the battle for progress in medical science has been largely fought by pioneers, alone and single-handed. This has been true not only in medicine but in all other branches of science and to a lesser extent in the development of business, which has today achieved a position worthy of rank next to science itself. In late years, however, a new force has made itself felt in the battle for progress—organization, which in many instances has been able to achieve what individuals had long striven for in vain. Its achievements are due largely to the modern application of an old saw "In union there is strength," exemplified by the Romans when they showed the ease of breaking a single stick across the knee and the utter impossibility of doing the same with the sticks bound into a bundle or *fascis*—the venerable legend from which the Fascisti of today took their name.

Quackery, patent medicines, and many "pathies" and "isms" were rampant when the American Medical Association under capable leadership began its now famous "propaganda for reform." While it is true that not all of the wrongs have been righted, it is nevertheless a fact that today the world of medicine, and therefore the world at large, is better off because of the valiant efforts of the A. M. A. Its work is by no means finished but great forward strides have been made and in the accomplishments of the past few years lies the hope of future progress.

The above is submitted by the editor as a preamble to a suggestion for what he conceives to be a badly needed crusade for reform in the field of roentgenology and radium therapy. It is suggested that the roentgenologists of America organize a "propaganda for reform" of their own.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY has in mind the establishment of a "column" which may develop shortly into pages, to do for roentgenology what has been done by the A. M. A. in the field of drugs through its Council of Pharmacy and Chemistry.

Our field is a fertile one for the charlatan. There is too much inexpert roentgenology being done today. The steps taken by the city of New York, the state of Texas, and other communities requiring the licensing of roentgen laboratories are moves in the right direction but much remains to be done. Advertisements are constantly appearing in the newspapers showing the replica of the old-time quack sitting before the fluoroscope and viewing the "innards" of his victim with all the anticipatory glee of the pleasure and profit before him that was present in the Roman crowds just prior to turning "thumbs down."

As self-respecting practitioners of medicine we can never be content until the medical practice acts are so amended as to recognize the practice of roentgenology and radium therapy as the practice of medicine.

The editor already has some material on hand and will be glad to receive advertisements, circulars and general information about practitioners of roentgenology who should not be practicing. Suggestions and information along these lines is requested from all legitimate sources. THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY will not be found backward in lending its assistance and the weight of its prestige to the beginning and carrying on of a *real*, new, and practical Propaganda for Reform in Roentgenology. It is hoped that the Safety Committee or the Committee on Laws and Public Policy of the American Roentgen Ray Society may assume a position in our domain analogous to that of the Council on Pharmacy and Chemistry of the A. M. A. More of this later.

In the meantime, it is hoped that the idea will take root in order that we may all cooperate for the advancement of our science.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this column solicited promptly after the events to which they refer.

TWENTY-FIFTH ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

THE American Roentgen Ray Society convened for its Twenty-fifth Annual Meeting at the New Ocean House, Swampscott, Massachusetts, on the morning of September 3, 1924, with Dr. Hollis E. Potter, President of the Society, presiding.

Dr. Enos H. Bigelow, President of the Massachusetts Medical Society graciously welcomed the members of the American Roentgen Ray Society and expressed the appreciation of the medical profession for the work being accomplished by roentgenologists.

The President-Elect, Dr. George W. Holmes of Boston, was then installed as President of the Society.

In the absence of the Secretary, the President appointed Dr. Charles L. Martin Secretary, pro tem.

The scientific program was then begun and continued throughout four days and two evening sessions. The papers will be published in the Journal as rapidly as possible and no attempt will be made to abstract them in this brief report of the meeting. The wide range of the program may be judged by the fact that those who contributed to it included surgeons, internists, physicists, biologists, physiologists and pathologists, as well as roentgenologists and radium therapists. This is also an indication of the growing importance of roentgenology and its far-reaching ramifications. Some idea may be obtained of the unusual quality of the material presented by a list of a few of the names of those who addressed the meetings. Surgery was represented by such names as Harvey Cushing, E. A. Codman, James Heyman, D. Crosby Greene, W. Jason Mixter, and Charles A. Porter. The latter presented a paper profusely illustrated with lantern slides on "The Surgical Treatment of *X*-ray Lesions," a subject upon which he is probably better informed, and a field in which he has had a wider experience, than any other man.

Internal medicine could not have been represented by one better qualified to speak for it than Richard C. Cabot, Professor in Harvard University, who addressed the Society at its annual banquet on the subject, "Impressions as to the value of the *X*-ray in Internal Medicine."

Pathology needed no other representatives than James Ewing, S. Burt Wolbach and C. H. Bunting. The American Roentgen Ray Society at this meeting showed its appreciation of the great debt of roentgenology to James Ewing by electing him an honorary member of the Society.

Professor William Duane contributed a paper on "The Modern Conceptions of *X*-radiation." Dr. Duane's assistance to roentgenologists in the field of physics has been invaluable. The great esteem in which he is held was shown by his election this year as an honorary member of the Society.

Dr. G. Failla, of the Memorial Hospital of New York City, another physicist whose work has aided in the progress of roentgenology, and whose contributions to our programs are always helpful and interesting, read a paper on "A Precision Method for the Administration of *X*-rays."

The seemingly formidable subject, "The Relation between Physiological Dominance and the Biological Effects of Rays" was rendered exceedingly interesting by the presentation of Professor W. T. Bovie of Harvard University.

That the members of the American Roentgen Ray Society are intensely interested in the progress of roentgenology is shown by the large number of papers presented at every meeting descriptive of some piece of research work. The following is a partial list of such papers presented at this meeting in addition to those already

mentioned: "A Preliminary Report on the Effect of *X*-rays on Collagen," by Dr. S. Burt Wolbach; "Can the Thymus Gland be Stimulated by *X*-rays?," by Dr. Maurice Lenz; "The Influence of High Voltage Irradiation on Salivary Secretion in Dogs," and "The Effect of Deep Radiation on the Sensitivity of Buccal Mucosa," by Dr. James T. Case and Professor W. N. Boldyreff. (Dr. Boldyreff is a physiologist who was formerly first assistant to Pavlow at St. Petersburg.) "Effect on Tumors of Radiation of Different Wave Lengths," by Dr. Francis Carter Wood; "The Effect of Roentgen Rays on the Adrenal Gland," by Drs. Charles L. Martin, Fred T. Rogers and N. F. Fisher; "A Comparison of the Roentgen-ray Output from Various Roentgen-ray Generators," by Dr. W. Edward Chamberlain; "Physical Standards of Protection against *X*-ray Dangers," by Dr. A. Mutscheller; "Immediate Metabolic Disturbances following Deep *X*-ray Therapy," by Drs. Howard P. Doub, Frank W. Hartman and A. Bolliger.

It would not be feasible nor profitable to give in detail the many diagnostic and therapeutic subjects which were discussed. They varied in the diagnostic field from such relatively unusual subjects as that of Dr. Pirie on "The Action of *X*-rays on Corns," and Dr. Leonard on "Further Observations on the Use of the *X*-ray in Pertussis," to more common subjects such as that of Dr. N. Smith-Petersen on "Clinical Diagnosis of Common Sacroiliac Joint Conditions," and Dr. Aspray on "Examination of the Nasal Accessory Sinuses." Dr. Carman made a timely contribution to the program in his presentation of the results obtained in diagnosis of gall-bladder disease by Graham's method of injection of the sodium salt of tetrabromphenolphthalein. This will be found complete in this number of the Journal.

The Society was very happy this year in having as its guest Dr. Gösta Forssell of Stockholm, who delivered the Caldwell Lecture. This lecture was published in the Journal last month.

Hardly less fortunate were we in having Dr. James Heyman, a gynecologist associated with Dr. Forssell, who gave an account of "Final Results in the Treatment of Carcinoma of the Uterine Cervix at 'Radiumhemmet' in Stockholm."

In a previous issue of the Journal we have mentioned editorially the address of Dr. Codman on "The Nomenclature of Bone Sarcoma," and his description of the method of registration of bone tumors. The importance of this work can scarcely be exaggerated.

An interesting incident of the Thursday morning session was the introduction of Dr. Francis H. Williams. The President, Dr. Holmes, introduced him with the following words: "The speaker this morning is one of the pioneers of roentgenology; probably most of you know him, but perhaps some of you do not know that he gave the first bismuth meal to a human being and made the first examination of the gastrointestinal tract; not only was he the first in America but the first in the world to report such an examination." We are glad to be able to publish in this issue the portrait and some account of the work of Dr. Williams.

At one of the executive sessions two others besides Dr. Ewing and Dr. Duane were elected to honorary membership in the Society. One of these is an old friend of our Society and one of the foremost roentgenologists of the world, Dr. Robert Knox, of London, England; the other is one whose death we have been called upon to mourn since our last annual meeting, Dr. R. Walter Mills, of St. Louis.

The following officers were elected for the ensuing year: President-Elect, Thomas A. Groover, Washington, D. C.; First Vice-president, Joseph Steiner, New York City; Second Vice-president, John Murphy, Cleveland; Secretary, C. L. Martin, Dallas, Texas; Treasurer, W. A. Evans, Detroit, Mich.; Librarian, Harry Dachtler, Toledo, Ohio. E. H. Skinner of Kansas City was elected to the Executive Council for the usual three-year term.

The scientific exhibit this year was one of the largest and best that we have ever had. The thanks of the Society are due to Dr. MacMillan of Boston for his painstaking work in its preparation. The commercial exhibit was also excellent. It is greatly regretted that circumstances made it necessary to hold the exhibits

at a distance from the place of meeting. The patient and forbearance of the exhibitors under trying circumstances was greatly appreciated but every care will be exercised in the future to hold the exhibit in close proximity to the meeting place.

The entertainment features at the meeting prepared by the Boston members and their ladies were very greatly appreciated and enjoyed. These consisted of a ride to the many places of historic interest in and around Boston, a clam bake on the shore, and a golf tournament, besides dancing in the hotel ballroom each evening. Dr. George, chairman of the golf committee presented two beautiful prizes, one for the best gross and the other for the best net score. Dr. Willis Manges was the winner of the former, and Dr. Mark Brown of the latter.

From every aspect the meeting can be considered one of the best we have ever had.

ANNUAL MEETING RADIOLOGICAL SOCIETY OF NORTH AMERICA

The annual meeting of the Radiological Society of North America will be held in Kansas City, Mo., December 8—12, 1924. The headquarters are at the Hotel Muehlebach. A one and one-half fare rate for the round trip to Kansas City has been arranged for on the certificate plan. Each one who attends the meeting should secure a cerificate when buying his railroad ticket to Kansas City and deposit it with the railroad clerk at the registration desk in the Hotel Baltimore as soon as possible after arrival. After validation they are good for one-half fare on the return trip over the same route. Arrangements have been made for a special train to leave Union Station, Chicago, Sunday night, 12.30 A.M., December 8. Further information may be obtained from Dr. I. S. Trostler, 812 Marshall Field Annex, Chicago.

WILLIAM HENRY BEAUFORT AIKINS, M.D., C.M., L.R.C.P. (LOND.), F.A.C.P. 1859–1924

Dr. W. H. B. Aikins, of Toronto, died suddenly from angina pectoris while at work in his office, October 2, 1924.

Dr. Aikins was the son of the late Hon. J. C. and Mary E. J. Aikins and was born at "Richview," Peel County, Ontario, on August 22, 1859. He began his long academic training by entering Upper Canada College. In 1881 he graduated with the degree of M.B. from the University of Toronto and M.D.C.M. from Victoria University. Then followed two years of post-graduate study in New York, London, Edinburgh, Paris and Vienna. He took his licentiate in London, England, in 1881, and the General Medical Council examination of the United Kingdom in 1883. He registered in Ontario on November 1, 1883, and from that date until his death he practised in Toronto.

Always in the forefront of the advance of medicine, Dr. Aikins was one of the first to study treatment by radium, and he had a large quantity of radium at his command. He followed very closely the early work of Wickham, of Paris, and together with Robert Abbe, of New York and Howard Kelly, of Baltimore, was the first on this continent to use radium therapeutically. He was active in many medical associations which were eventually amalgamated in the Toronto Academy of Medicine, and was a past president of the Academy itself. He was one of the proprietors and editors of The Canadian Practitioner, and made many contributions to medical literature, particularly on the subjects of cancer and radium. For a number of years he was physician to the General Hospital, Toronto, and at his death was a member of the consulting staff of Grace Hospital. He has acted also as consulting physician to the Toronto Hospital for Incurables and the King Edward Sanitarium. He was identified with the former institution for nearly forty years and took a prominent part in the steps which led to its successive expansions.

Dr. Aikins was one of the organizers of the American Radium Society, of which he was the first president. He was a member of the Ontario Medical Association, the Canadian Medical Association, and the British Medical Associations, and was a Fellow of the American College of Physicians and also of the Royal Canadian Institute, London, England. DOUGLAS QUICK.

DEPARTMENT OF TECHNIQUE

Department Editor: DAVID R. BOWEN, M.D., Pennsylvania Hospital, Philadelphia, Pa.

In this department will be published from time to time, as material is available, suggestions for improvement in technique.

TECHNIQUE FOR MASTOID EXAMINATION*

BY JOSEPH ASPRAY, M.D., AND FREDERICK K. HERPEL, M.D.

SPOKANE, WASHINGTON

STEREOSCOPIC roentgenographic examination of the mastoids is not new, and various techniques have been described for such examination. Likewise the taking of both mastoids, stereoscopically, on a single set of films, is not new. The technique which is used in our laboratory, however, is distinctly different from that usually followed, and has not to our knowledge been previously described in the literature.

Any standard roentgenographic technique, to be acceptable to the majority of roentgenologists, must be relatively easy to carry out; applicable to the majority of patients of all ages; capable of being repeated with reasonable accuracy; and the resulting roentgenograms must show certain constant land-marks.

Examination of both mastoids, stereoscopic views in the lateral projection, is made on two 8 × 10 duplitized films, using the double-screen film technique.

A 23 degree angle board is slotted to accommodate a standard 8 × 10 cassette. The face of the angle board is covered with a thin piece of sheet lead, in which are cut two circular openings, four inches in diameter. A space of about one-half inch is left between the openings, which are placed midway between the sides of the film in the short dimension.

The angle board is placed on the horizontal roentgenographic table, and the tube centered over the right opening in the lead covering sheet (the opening farthest from the tube stand, which is placed on the blind side of the slotted angle board). The tube stand arm is horizontal, parallel with the table top. The tube having been centered, the stereoscopic shift is set and locked. A piece of sheet lead, covering half of the face of the angle board, is then placed over the left side of the board. The tube is raised to the top of the tube stand. The patient lies prone on the table, with arms extended upwards along the sides of the angle board. The right mastoid is now centered on the right opening in the lead covering sheet, the pinna brought forward, the head horizontal, with the mastoid as close as possible to the face of the angle board. The right mastoid is always exposed first. Cassette number 1 is then placed in the slot in the angle board. The tube is brought down to fixed mark on the tube stand, 23 inches being our standard distance, using a four inch Kelly-Koett cone.

Exposure number 1, of the right mastoid, is now made on cassette number 1, with the central ray from the tube vertical to the table top, *without* shift or tilt of the tube. The angle of the central ray, with relation to the mastoid, is approximately 20 degrees toward the feet, with practically no forward angle.

Cassette number 2 is now placed in the angle board and cassette number 1 removed. A shift, *half* of the usual stereoscopic shift, one and one-sixteenth inches, is then made to the right, if the right mastoid is the supposedly pathological mastoid. If the left mastoid is suspected, this shift is made to the left. A tube tilt of 5 degrees is made toward the side opposite to the shift. Exposure number 2, of the right mastoid, is now made on the right side of cassette number 2.

The tube stand is raised, and the head of the patient removed from the angle board. The right side of the face of the angle board is covered with the sheet lead. The tube is centered over the left opening in the lead covering sheet. The stereoscopic shift

* Read before the Joint Meeting of the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY and THE PACIFIC COAST ROENTGEN RAY SOCIETY, Seattle and Mt. Rainier, Washington, July 22, 1924.

is locked. A shift of the tube, *identical* with that made for exposure number 2,

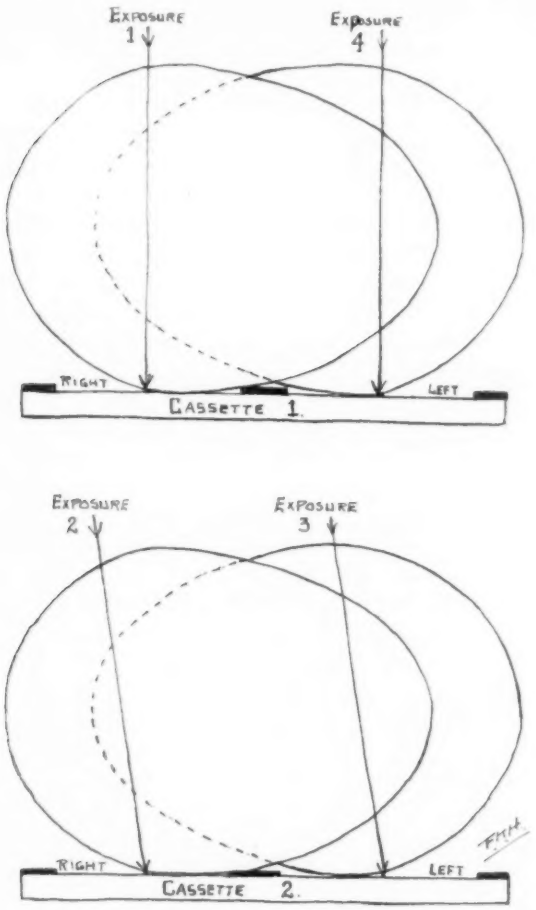

Diagram illustrating technique of roentgenographic examination of both mastoids on a single stereoscopic set of films (8″ × 10″).

(1) Patient prone on table, with head on 23° angle block, right mastoid in center of right opening in lead covering sheet. Left side of film covered.

(2) Exposure 1, of right mastoid, on cassette 1, central beam of ray vertical to table top.

(3) Remove cassette 1 from angle board and insert cassette 2. Exposure 2, of right mastoid, on cassette 2. Central beam of ray directed at angle of 5° toward front of head, with half stereoscopic shift toward back of head.

(4) Right side of face of angle board covered with lead sheet. Left mastoid centered in left opening in covering lead sheet exposure number 3, of left mastoid, on cassette 2. Central beam directed at angle of 5° with half stereoscopic shift, shift and tilt identical with that for exposure 2.

(5) Remove cassette 2, and reinsert cassette 1, exposure 4, of left mastoid on cassette 1 with central beam of ray vertical to table top.

is now made, and a 5 degree tilt, as before. This feature of the technique is important and differs from that usually followed in that for one mastoid the shift is toward the back of the head and the tilt forward, while for the opposite mastoid the shift is toward the front of the head and the tilt backward. Theoretically this cannot result in stereoscopic sets which are identical. From a practical standpoint, however, we have been unable to detect any material difference in the detail of the right and left mastoids, and seldom can we detect which mastoid was the correctly (?) exposed one.

The left mastoid is now centered on the left opening in the lead covering sheet, and the tube brought down to 23 inches, as for the right mastoid. Exposure number 3, of the left mastoid, is now made on the left side of cassette number 2. The tube is then returned to the center of the stereoscopic shift, without tilt. Cassette number 2 is removed from the angle board and cassette number 1 replaced. Exposure number 4, of the left mastoid, is made on the left side of cassette number 1, with the central ray passing through the left mastoid vertical to the table top.

The resulting films stereoscope both inside out and outside in, on the same level, and with the mastoid area occupying the same relative position in the circular exposed area. For practical diagnostic purposes, and that is the aim of our technique, the two mastoids are the same in their exposure, position and demonstration. We believe that film number 1, made with the central ray directed through both mastoids vertical to the table top, approximately 20 degrees toward the feet of the patient, is a film of decided value for the roentgenologist as well as the surgeon or aurist. This film may be viewed singly, with accurate comparison of the two mastoids. Many surgeons do not have stereoscopes to examine stereoscopic films. This film shows an exposure of the right and left mastoids from which accurate comparisons can be made with respect to mastoid area, detail, density, type and relationships. The taking of the stereoscopic set in the manner which we have described gives us this flat film for examination without the stereoscope. The use of the usual full stereoscopic shift and tilt

in both directions does not give us this film. Taking the stereoscopic set in the usual manner would necessitate the taking of a third film to secure a film for accurate comparison without the stereoscope. We believe that from the standpoint of economy we have justified the use of the half stereoscopic shift as we use it in our technique.

Any flat film, however taken, we hold to be insufficient and incomplete for a satisfactory examination of any mastoid. We feel, therefore, that wherever possible a stereoscopic set should be taken, and that each film of the set should show both the right and left mastoid area.

The stereoscopic set demonstrates the mastoid areas completely and satisfactorily. This technique is flexible in that the shift and tilt are so made for the exposures on film 2 that the angle for the suspected pathological mastoid is downward and forward. We have taken stereoscopic sets on the same individual at intervals of two months in which the resulting roentgenograms are almost identical, and in which three technicians participated in the taking of the respective roentgenograms.

The advantages of this technique over other and usually described techniques, as they appear to us, are:

1. Standardization of technique.
2. Simplification of technique.
3. Facility of performance.
4. Elimination of the personal factor in the positioning of the patient, the film and the roentgen tube.
5. Certainty of accurate duplication for comparison.
6. Superiority of the resulting stereoscopic films for diagnostic purposes.
7. One film of the stereoscopic set, showing both mastoids with identical exposures and demonstration, superior for examination without stereoscope.

Editor's Note. We have, for several years, made stereoscopic examination of the mastoids, with position 1 practically identical with that described in this paper; but using the full shift for position 2 and tilting the cone sufficiently to cover the same area as position 1, and we suggest a trial of that modification of the above technique. We believe it improves the stereoscopic impression.

D. R. B.

INTERNATIONAL ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SIMON, W. V. Sarcoma of the bone. *Ergebn. d. Chir. u. Orthop., Berl.*, 193–483.

In this extensive publication, the author sets forth the value of roentgen examination in the diagnosis of bone sarcoma. However, the roentgenogram may be difficult of interpretation and may lead to erroneous conclusions. Haenisch has shown that sarcoma and chondrosarcoma may appear as a cyst in the roentgenogram. They may leave the cortical layer uninvolved for a long time; or they may attack the entire cross section of the bone, and lack peripheral growth. Traumatic periostitis may be confounded with sarcoma; however, in traumatic periostitis the bony structure is a well-defined tumor. Subperiosteal traumatic hematoma may also give rise to errors, as was reported by Starker. The anamnestic fact that hemophilia had existed prevented an error in diagnosis in this instance. There was, in this case, an extensive destruction of the bone; and protrusions into the soft parts which are typical of the sarcoma roentgenogram, were present between the cortical layer, and the loosened periosteum. Syphilitic periostitis and periosteal or cortical gummata may produce pictures resembling periosteal sarcoma. Increase in calcareous content, absence of periosteal spindles, small size of the soft part tumor are proofs against sarcoma. Osteomyelitis, especially the sclerosing, non-purulent type, is readily confounded with sarcoma. In this instance the antistaphylolysin reaction will be of use.

The former difficulty in the differential diagnosis between articular tuberculosis and sarcoma is now often cleared away by a glance at the roentgenogram; but even with this aid early diagnosis may be difficult.

CZEPA, A. Demonstration of the appendix in the roentgenogram. *Wien. klin. Wchnschr.*, July 3, 1924, xxxvii, 673–674.

Examination of 144 patients who had no evidence of appendicitis disclosed 26 in whom the appendix became filled with contrast material. All but 3 of the 26 showed emptying of the appendix within 48 hours. It is concluded that mere observation of the filling of the appendix with contrast material lasting 24 to 30 hours is no basis for a conclusion as to the condition of the appendix. It seems certain however that retention of the filling for longer periods is not normal. Observation of the contrasted appendix made during suitable manipulations may give information as to kinking, stenosis, adhesions, etc.

FLEISCHNER, FELIX. Mediastino-interlobar pleuritis—a frequent occurrence in tuberculosis of the mediastinal glands. *Acta radiol., Stockholm*, August 25, 1924, iii, 307–326.

It is shown by 5 examples cited that an exudative pleuritis in the mediastinal and interlobar pleural space, especially to the right between the middle and lower lobes frequently occurs in the course of tuberculosis of the mediastinal lymph nodes. This complication is explained by the extremely close relation of certain groups of glands to the pleura. Besides roentgenoscopy in the ordinary position, an examination in the "saddle-back" position is especially suited for demonstrating this exudate. In this position, shadows that were previously quite indefinite collect to form dense, sharply circumscribed shadows, triangular, beak or spur-shaped, and situated close to the middle shadow.

Presence of such an exudation in cases where "gland tumors" are not readily demonstrable, permits discovery of an affection of the mediastinal glands which are covered by the median shadow. The illustrations shown confirm the advice of many writers to call at once any enlarged hilus shadow tuberculous hilus glands or else hilus tuberculosis. Pleuritic processes in the mediastinal and interlobar pleura may cause enlarged hilus shadows.

KNOX, R. Radiography of the gall bladder. *Acta radiol., Stockholm*, August 25, 1924, iii, 265–296.

The first and most important essential for successful roentgenography of the gall bladder is a technique that permits rapid exposures with complete immobility of the part under examination. The question of purgation preceding examination and the time when food is given are also of importance. The composition of the gall stone has an important bearing upon its appearance in the roentgenogram. Pure cholesterin produces only a very faint shadow readily obscured by other structures. In examining for the presence of gall stones it may be that ordinarily the ring type of shadow is sought and the diagnosis may be missed if the observer fails to realize that a small "negative" opacity may indicate presence of a stone.

The differential diagnosis in lesions of the right upper quadrant of the abdomen is very

difficult because of the many important organs in that region, hence every known method must be employed in the investigation of difficult cases. Amongst others, pyelography has a definite field of usefulness. Lateral roentgenography and pyelography are of first importance in differentiating between kidney and gall stones. Most of the difficulty in the roentgen diagnosis of gall stones is largely due to their density, and it becomes at once clear that any movement of the patient whether voluntary or involuntary during exposure may modify the roentgenographic value of the negative. It is quite possible that movement of the gall bladder and ducts during a roentgen exposure may be sufficient to spoil a good negative. Likewise movement of other organs in the region such as duodenum and stomach and aorta may have a similar effect. Consequently as short an exposure as possible is necessary in work of this kind.

MØLLER, P. FLEMMING, and PERMIN, G. E. Annular shadows in the roentgen picture as indications of localized pneumothorax. *Acta radiol., Stockholm*, August 25, 1924, iii, 297–306.

A description is given of 4 cases of pulmonary tuberculosis in which the roentgen pictures showed marked annular shadows, although all other clinical examination failed to reveal the presence of any cavity. These annular shadows are described as circular patches the size of a penny, surrounded by a denser area. In 3 of the cases a roentgen examination made at a later date showed the annular shadow to have disappeared; while in the fourth case the shadow persisted but its size varied markedly from time to time, although there were no definite signs of any cavity. From the evidence at hand it is believed that in these cases there could not have been any cavities present. The only explanation, therefore, of these small annular formations is that they represent localized temporary pneumothorax.

PANCOAST, HENRY K. The *x*-ray diagnosis of chest infections in childhood. *Arch. Pediat.*, March, 1924, xli, 193–199.

From the roentgenologic standpoint the greatest difficulty encountered in chest findings is in the correct interpretation of the appearances arising from the respiratory infections.

The acute infections may affect the normal appearance in one or all of three ways: enlargement of the tracheobronchial lymph nodes, intensification of the hilum and trunk shadows and linear markings, and prominence of the normally faint shadow of the lung parenchyma. In acute bronchitis the first two changes are usually found whether the condition be a simple acute cold or a complication with one of the infectious fevers. Correct etiological interpretation can only be made in conjunction with the clinical observations. Lobar and bronchial pneumonia present very characteristic appearances theoretically but lack of cooperation of the patient and his youth impedes interpretation. Sometimes a roentgen-ray examination may reveal the nature of the condition before the physical signs become definite.

Bronchopneumonia as a chronic infection may take on appearances which cannot be differentiated from tuberculosis. Pulmonary tuberculosis in early childhood presents quite a different roentgenographic appearance from that found in the adult and this picture is not nearly so characteristic. In the early stages the prominent features are found in the hilum regions and later on the parenchymal regions are invaded with the production of the typical mottled appearance if the case is seen before consolidations occur. In the typical early case there is an enlarged hilum shadow with increased density and glands more or less discrete, and very much accentuated trunk shadows.

SCHOLZ, THOMAS. Calcification of the heart: Its roentgenologic demonstration. *Arch. Int. Med.*, July 15, 1924, xxxiv, 32–59.

A review of the literature is presented together with theories on myocardial calcification in conjunction with a case which is cited. The patient was observed roentgenoscopically and there was found a picture of calcification in the aorta together with a ring-like shadow at the apical portion of the heart. Examination of the heart at necropsy showed in the lower half of the left ventricle a cup-shaped area of complete calcification extending about 5 cm. from the apex. The external aspect of this calcified cup was covered by thin layers of fibrous pericardium. The coronary arteries were thickened and calcified to veritable pipe stems. The aorta had a number of calcified plaques.

Review of the literature shows that pathologic calcification may be due (1) to deposition of calcium salts in dead or markedly deteriorated heart tissue, and (2) to calcium precipitation which involves the endocardium only, this being an extremely rare occurrence. The latter is observed in combination with so-called calcium metastasis. If calcification of the heart is extensive enough it may be demonstrated roentgenologically *intra vitam* and may even be differentiated from pericardial calcification. Small calcified foci cannot be demonstrated in this manner during life. The pathologist should find the roentgenogram useful in discovering calcified foci.

ALLEN, BUNDY. Nasal accessory sinuses in infants and children. *Radiology*, August, 1924, iii, 136–139.

Practically every case of sinusitis in children will become chronic if not properly treated. The routine roentgen-ray examination and treatment of the pathological sinuses of children will in a large measure obviate the chance of the lesion becoming chronic in adult life. Five cases are cited as illustrations.

ALLISON, ROBERT G. Dilatation and atony of the stomach in severe diabetes. *Radiology*, September, 1924, iii, 222–224.

A case occurring in a woman aged 20 is described in detail. There was no evidence of abnormality of the gastrointestinal tract. The roentgenogram showed at first extensive dilatation and complete atony of the stomach. Following treatment for diabetes, the stomach returned to normal size and apparently normal function.

BIERMAN, MORRIS I. Diaphragmatic hernia, non-traumatic. *Radiology*, September, 1924, iii, 233–239.

Three cases are described, all being diagnosed with the aid of the roentgenogram. The most important conditions from which diaphragmatic hernia must be differentiated and which are most confusing clinically are hydrothorax, peumothorax, hydropneumothorax, lung abscess, tumors and eventration of the diaphragm. The physical signs are confusing but with the diagnostic aid given by the roentgen ray the differential diagnosis is relatively simple. The prognosis is not of the best, strangulation occurring in about 15 per cent of the cases.

CARMAN, RUSSELL D., and DAVIS, KENNETH S. Roentgenologic evidence of spinal-cord tumors: Report of three cases. *Radiology*, September, 1924, iii, 185–188.

It is impossible to demonstrate spinal cord tumors themselves roentgenographically because of the density of the vertebrae and the complexity of their anatomy. The practical value of direct roentgen evidence is slight since only 3 out of 119 certified cases gave positive roentgen evidence. The roentgen diagnosis is made possible only by sufficient erosion of the laminae of the vertebrae or of the vertebrae themselves so that the erosion having the appearance of a bony cyst can be recognized in the roentgenogram. Of the 3 cases described the first was an intramedullary tumor, the second an ependymal glioma of the cauda equina and the third an extradural tumor.

CARTER, L. J. Pathology in the right upper abdomen. *Radiology*, September, 1924, iii, 189–196.

This is a contribution toward the statistical record of the value of roentgen-ray signs as proven by operative findings in 164 cases. Disease in the right upper abodmen is intimately associated with ileocecal disease, a fact that should not be forgotten in considering surgical procedure. The closely interrelated pathological processes occurring in this region (in their order of frequency) are gall-bladder disease, bands or adhesions, and disease of the duodenum. The gall-bladder and the appendix are the commonest sites of adhesions, while the duodenum and ileocecum the commonest sites of bands. Roentgen-ray signs in a normal right upper abdomen may be produced reflexly from ileocecal disease. The gall-bladder can be visualized roentgenographically in at least 85 per cent of the proved cases and gall-stones in 75 per cent. It is believed that the visualized gall-bladder is always pathological. The indirect evidences of gall-bladder disease (tenderness, deformity of duodenum due to adhesions, spasm or gall-bladder pressure, hyperperistalsis) are considered of absolute value in determining diagnosis. The presence or absence of adhesions can be determined by variations in the grouping of this sign-complex.

DAVIS, KENNETH S. Pulmonary fibrosis. *Radiology*, August, 1924, iii, 150–157.

The clinical picture of fibrosis is not at all characteristic, the outstanding feature being that in spite of long duration of symptoms the general health is but little impaired. The roentgenogram is also uncharacteristic but varies according to the etiology, origin and extent of the fibrosis, the dilatation of the bronchi and the pleural changes. The earliest changes are most often seen at the hilus, later extending as small bands along the bronchial tree into the fields of the lung. In tuberculous fibrosis the process begins in the apex, and in the pleurogenic type it begins at the periphery of the lung. Usually the infiltration spreads first to the lower lobes, the upper ones being involved later. Massive fibrosis is almost always unilateral and is regarded as a rare occurrence.

Cases have been reported in which patients receiving intensive doses of roentgen rays directed to the chest have developed symptoms which in time showed definite areas of lung infiltration with or without pleuritic involvement. There is a definite thickening of the hilus from which fibrotic bands extend out into the involved area. The mediastinal structures are pulled toward the affected side and there is

definite restriction of lung expansion. In all the cases reported the condition was unilateral. It is still a matter of uncertainty since in none of the biopsies reported has there been conclusive evidence that the fibrosis was produced by the roentgen rays.

The lesion most closely simulating fibrosis is that of primary or secondary infiltrative carcinoma. In massive fibrosis a differential diagnosis is rarely possible from the roentgenogram alone. Empyema, adhesive plastic pleuritis, pneumonia with pleural involvement may all have a similar appearance in the roentgenogram.

DIEMER, FREDERICK E. Check fractures. *Radiology*, August, 1924, iii, 160.

Study of bone roentgenograms taken by means of a very fine focus tube reveals in certain cases of "strain" and "sprain" no gross break in continuity. There is observed, however, a slight disparity of minute bone detail with an indefinite, quite indistinct line of abnormality. This is regarded as evidence of "check fracture" with either extremely slight impaction on one aspect with the same degree of slight separation on the other, or with extremely slight impaction on all sides.

This fracture is most common in the fibula at either of its ends. The skull is also quite commonly the site of this fracture and the ribs are next most frequently involved. It also occurs in the radius and the tibia. These check fractures are often caused by indirect violence—turn of ankle, fall on extended arm, etc. Green stick fractures can be differentiated because they present a break in continuity.

EISEN, PAUL. A rational method for demonstrating the heart. *Radiology*, September, 1924, iii, 225–227.

To avoid distortion of the roentgenogram of the heart in very stout persons a special technique is necessary. The heart is first studied roentgenoscopically and the correct point for the central horizontal ray is noted, as is also the degree of inspiration which the patient is able to accomplish. The roentgenogram is taken with the focal point at the tenth rib and the patient made to take an extremely deep breath, holding it a second with open mouth. There is thus obtained not only a correct heart shadow, but one entirely separated from the shadow of the diaphragm. The central ray is above the dome and the lower divergent ray runs parallel with the front slope of the diaphragm so that a sharp demarcation is obtained between the lower heart boundary and the shadow of the diaphragm.

This method has the further advantage of producing greater contrast between the heart and the better aerated lung tissue. A well marked bifurcation of the trachea should be the criterion of correct exposure and development of the roentgenogram. Speed is of the utmost importance and the larger the patient, the greater the speed required, and the greater should be the distance between focus and film. It should be remembered that the method described does not allow twice the heart diameter to tally with the chest diameter as obtained by the older method.

GRANGER, AMEDEE. The value of the Granger line in the diagnosis of disease of the sphenoid sinus, with illustrative cases. *Radiology*, September, 1924, iii, 208–215.

Roentgenograms of skulls held in the Granger alveola-glabella position on 107° and 23° angle blocks show that the Granger line is produced by that portion of the upper surface of the sphenoid bone called the optic groove. Of the various other lines seen this is the most important. By a careful study of it and of the subjacent area, the sphenoid region, it was possible to determine whether the sphenoid sinus was diseased or not, and when diseased to state with a degree of accuracy, impossible up to this time, that it contained pus, polypi or hyperplastic tissue. Ten cases are described and illustrate the normal sphenoid sinus and pathological conditions such as polypoid sphenoiditis, hyperplastic sphenoiditis, vacuum sphenoid, etc.

GROOVER, T. A., CHRISTIE, A. C., and MERRITT, E. A. Pulmonary tuberculosis as a cause of pain in the shoulder. *Radiology*, September, 1924, iii, 183–184.

Among the numerous causes for referred pain of the shoulder pulmonary tuberculosis appears not to have received the consideration that its importance merits. It is, of course, not to be inferred that a lung lesion is the cause of shoulder symptoms in all cases, and a causal relationship can be established only when other causes have been properly weighed.

The ordinary roentgen examination of the shoulder is seldom made so as to be of value in recognizing intrathoracic disease. The lung lesion as seen roentgenographically has the characteristics of chronic pulmonary tuberculosis. Usually the disease extends high up in the apex and frequently well out toward the axilla. Definite thickening of the pleura at the apex can frequently be noted. The roentgen appearance may be that of an arrested or an obsolete process with areas of calcification. Not infrequently the lung lesion has been shown to be bilateral while the shoulder symptoms were unilateral. The cases in general were characterized by a paucity of signs and symp-

toms referable to the lungs. It is concluded that shoulder pain which is not otherwise satisfactorily explained should direct attention to the chest as a possible source of origin. In that case the roentgen examination of the chest may indicate the correct diagnosis.

PFAHLER, G. E. The study of tumors of the bladder by means of pneumo-roentgenography. *Radiology*, September, 1924, iii, 197–201.

Cystoscopy has been developed to a high degree of satisfactory service but there are many cases in which an examination by this means is not practical. In that event, pneumo-roentgenography can yield valuable service.

The technique followed is to make an anterior and posterior film of the bladder before injection of air. The urethral orifice is then cleansed and a soft rubber catheter is passed into the bladder. An atomizer bulb and a cotton plug for filtering the air are fitted to the catheter in a suitable manner, and sterilized before use. Residual urine is removed from the bladder and air is then injected or compressed into the bladder until the patient complains of distress, distention or desire to urinate. With due attention to the complaints of the patient no harm can be caused by the air injection. When the bladder is fully distended a pair of hemostatic forceps is clamped over the catheter tube and the latter fastened to the thigh with adhesive plaster. The atomizer bulb is disconnected. With the patient lying on his back upon a Potter-Bucky diaphragm, two films are taken using a soft tube so as to preserve detail. The patient is then turned prone and two more films are made with the central ray directed through the bladder obliquely forward and upward so as to project the sacrum and coccyx above the field of study. The air is then expelled from the bladder with the aid of compression in the suprapubic region.

A normal bladder will show an outline of gas with perfectly smooth walls; while in the case of a tumor the diseased portion will have an irregular outline. The technique permits the definite outlining of tumors so that an idea may be gained of their size, shape and general character. This method also permits observation of progress during the treatment of carcinoma of the bladder by radiation.

KIRSCHMANN, K. The roentgenogram of the heart in pulmonary tuberculosis. *Klin. Wchnschr.*, July 1, 1924, iii, 1227–1230.

Alteration in the position, size and shape of the heart are discussed from the practical standpoint. A good roentgenogram will reveal the heart boundaries within the shadow of an exudate, although roentgenoscopy may be unsuccessful. Mediastinal and costo-mediastinal fibrous adhesions readily displace the heart and can be determined definitely only roentgenologically. Pulmonary cirrhosis and cavernosis, especially on the left side, produce typical changes in the position and shape of the heart. In meteorism, the oblique position taken by the heart may resemble a dilatation, and the symptoms may be more severe than those due to the more serious cirrhosis.

The small heart of pulmonary tuberculosis is to be distinguished from the normally small organ. The latter has a ratio of 1:2 between its transverse diameter and the greatest frontal width. Great deviations from this ratio are to be considered pathological. The small heart in tuberculosis is caused by brown atrophy of the heart muscle. In this case the blood pressure is diminished. Roentgenologically, it can be recognized only after long observation has shown a measurable reduction in the heart size. In general, other things being equal, the roentgenogram of the heart in pulmonary tuberculosis is usually more faintly outlined than in the normal; and this is explained as due to hypoplasia of the myocardium and decrease in the blood volume. Enlargement of the heart during pulmonary tuberculosis is very rare and is found in advanced cases. It is caused by fatty degeneration.

LEVYN, LESTER. Madelung's deformity. *Radiology*, August, 1924, iii, 145–149.

This spontaneous forward dislocation of the wrist joint in 2 cases described by the author represents the fifth and sixth cases of this type cited in American literature. The deformity has a spontaneous onset and gradual development. The roentgenogram shows shortening of the radius and ulna with bowing of both. There is some backward displacement of the lower articular portion of the radius, and an excurvated, wedge-shaped appearance of the articular surfaces of the radius and ulna. The etiology of this condition is obscure, and the results of treatment have not been particularly encouraging.

LEWALD, L. T. Thoracic stomach: differentiation from eventration and hernia of the diaphragm. *Radiology*, August, 1924, iii, 91–104.

Thoracic stomach is of congenital origin, with development of the diaphragm below it without structural defect; and it remains at all times above the diaphragm. On the other hand, in diaphragmatic hernia, the stomach may be found at times below the diaphragm. In thoracic stomach, the short esophagus

enters the stomach above the diaphragm and the duodenum passes through the opening ordinarily occupied by the esophagus. This condition was observed in 2 patients, 7 and 69 years old respectively. In eventration, the diaphragm can always be made out above the stomach, especially in lateral exposures.

MEYERDING, HENRY W. X-ray findings in bone tumors: Exostosis, chondromas, bone cysts, osteitis fibrosa cystica, giant cell tumors. *Radiology*, September, 1924, iii, 216–221.

The true, benign osteogenic tumors, exostosis, chondroma and fibroma, can usually be differentiated roentgenologically. Exostosis may consist wholly of bone or of bone and cartilage. The bases of these exostoses arise from the cortex, and support the mass of bone and cartilage resembling a cauliflower-like growth. This and the clear differentiation of tumor are fairly characteristic. The growth does not invade the periosseous tissue but pushes its way through it. Chondromas are usually composed of hyaline cartilage and are difficult to distinguish from cysts, fibrocystic disease, giant-cell tumor or malignancy. Fibromas are rare and difficult to differentiate from cysts and chondromas.

Four illustrative cases are cited and a tabulated outline is given of the roentgenographic findings in benign bone tumors.

NEW, GORDON B. The roentgenologic diagnosis of pathologic conditions of the jaw. *Radiology*, August, 1924, iii, 165–167.

Slow-growing malignant tumors present similar characteristics in the roentgenogram to those of the benign type. It is often impossible to determine whether certain benign tumors are solid or cystic. Of the benign, solid tumors, the osteoma presents a dense shadow in single or multiple small masses around the jaw. Leontiasis ossei presents a diffuse thickening of the bone usually involving the nasal cavity up into the orbit. Solid odontoma presents a rounded mass of density similar to that of tooth structures, usually in a cystic cavity in the body of the jaw.

Of the benign cystic tumors, the multilocular cyst with trabeculation presents a characteristic appearance on the roentgenogram. Roentgenograms of malignant tumors vary, depending on the rate of growth. Endotheliomas and medullary carcinomas present a cystic cavity not differentiable from a simple cyst. Roentgenograms of rapidly growing epitheliomas or sarcomas reveal destruction of the bone and an irregular moth-eaten appearance of the remainder of the bone around the tumor. Osteosarcoma presents a diffuse bony mass which is difficult to differentiate from osteoma in the roentgenogram. There are no roentgenographic characteristics which differentiate metastatic from primary tumors.

RAVOLD, H. J. Hemangioma, with calcification: pre- and post-operative x-ray findings. *Radiology*, September, 1924, iii, 231–232.

Calcification is not a usual occurrence in hemangiomas, but when it does occur the diagnosis can usually be made only by means of the roentgen ray. The roentgenogram of this condition shows round or oblong bodies with concentric rings within. These calcifications are distributed irregularly, usually in the extremities. In the case described occurring in a girl fifteen years old, there were no surface indications of the condition for 8 years. Complete relief from pain was obtained by removal of the calcified nodules, 11 of which were extracted, the largest about 0.6 cm. in diameter.

SANTE, L. R. Cirrhosis of the lung. *Radiology*, August, 1924, iii, 128–135.

The pathology present and the roentgen findings vary widely in the types of so-called interstitial pneumonia. The present study is based upon 9 cases of this type. Nearly all were either pulmonary in origin following lobar or bronchial pneumonia or other complications, or had origin from a plastic fibrinous pleurisy. Atelectasis, long standing collapse of the lung by pressure from fluid, chronic fibrosis from dust inhalation and fibrosis incident to tuberculous involvement are essentially different processes and should not be included in this type of lesion. The most expressive term for the description of the condition outlined is "chronic diffuse interstitial fibrosis of the lung."

STEIN, I. F., and ARENS, R. A. The interpretation of early fetal roentgenograms. *Radiology*, August, 1924, iii, 110–117.

The roentgenogram of the fetal skeleton is regarded as the earliest demonstrable positive sign of pregnancy; and this sign is only rarely to be seen prior to mid-term. Adequate preparation of the patient to minimize intestinal contents is desirable. The dorsal posture with an increased lordosis produced by placing sand bags under the lumbar spine has proven most satisfactory for casting unobstructed fetal shadows on the film. The central ray is directed through the pelvis in the axis of the superior strait so that the entire true pelvis can be seen from below upwards without interference or overlapping of spinal, sacral

or pubic shadows. An estimate of the age of the fetus from the size of the fetal shadow can be made only very approximately.

STORDEUR, K. A case of roentgen injury. *Münchn. med. Wchnschr.*, May 9, 1924, lxxi, 617–618.

A girl now 12 years old received roentgen treatment 10 years ago for a tuberculous skin lesion of the right hand. The middle finger still shows an extensive roentgen atrophy of the skin with marked telangiectasis, and its length is 1 cm. less than that of its mate on the left hand. Roentgenologically, the affected finger shows retarded development of the phalanges. They are somewhat shortened and deformed and have poorly defined epiphyseal lines.

SUTHERLAND, CHARLES G. Report of case of myxoma of the lung. *Radiology*, August, 1924, iii, 161.

Roentgen examination revealed a circumscribed area of increased density in the right chest reaching the level of the fourth rib anteriorly. At operation the pleura was nonadherent and contained no fluid. The pleura was opened wide without effect on respiration, and a solid, fibrous tumor lay beneath the wound and was apparently not adherent to the chest wall. Two sections were removed and the pathologic report was myxoma. The mass was not removed and after the patient recovered from the operation, she was referred elsewhere for roentgen treatment.

VINSON, P. P. The value of the *x*-ray in the diagnosis and treatment of diseases of the esophagus. *Radiology*, August, 1924, iii, 105–109.

The roentgenographic findings in cancer of the esophagus are usually quite characteristic, the moth-eaten irregularity of the obstruction not being seen in other esophageal lesions. The extent of the malignant structure usually cannot be determined roentgenographically. In growths at the cardia, the outline may be smooth and the condition mistaken for cardiospasm. The differentiation of cardiospasm and diverticula of the lower end of the esophagus can be best accomplished by careful roentgenoscopic studies. Diverticula of the middle portion are rarely demonstrable unless there is an associated obstruction at the cardia. Negative roentgen-ray findings are useful in the diagnosis of functional or hysterical dysphagia.

WILLIAMS, E. G. C. A top for testing timing devices. *Radiology*, August, 1924, iii, 161–162.

The top consists of a lead disc 3½ in. in diameter with an aluminum sewing thimble pressed through a hole in the center for a pivot. The disc has a small triangular hole cut near the periphery. When this top is spun while an exposure of one-tenth of a second is made, the resulting film when developed should show a series of spots corresponding to the rectified current. Thus, if the timer is accurate there will be twelve spots on the finished film representing one-tenth of the rectified 60 cycle-second. This device is a simplification of the more elaborate one used by the testing department of the Victor factory.

VON ZEZSCHWITZ, PETER. The motion of the base of the posterior ventricular wall and of the left auricle. *München, med. Wchnschr.*, May 9, 1924, lxxi, 614–616.

An unusual opportunity for studying a phase of the mechanics of the heart was offered in a patient with a small shell splinter lodged in the heart muscle. This splinter ultimately worked its way into the superficial muscular stratum (the sino-spiral bundle) at the posterior sulcus. Roentgenoscopic observation revealed a most peculiar cycle of movements of the splinter during the heart beat. A series of roentgenograms carefully arranged gave a kinematographic representation of the movement.

The movement, resembling a skeletal muscle contraction, consisted of a large systolic contraction from the base of the ventricle progressing toward the apex and then back again. The muscle band involved is attached only to the underlying heart muscle at the posterior groove and this accounts for the wide excursion of the splinter.

BLUM, THEODOR. Primary carcinoma of antrum. *Radiology*, September, 1924, iii, 255–256.

Intra-oral roentgen films revealed an entire loss of bony structure in the left maxillary premolar and molar region. The soft swelling covered with normal mucous membrane, practically painless, in a patient past middle age is typical of early primary carcinoma of the antrum. The roentgen-ray examination readily excludes cysts as well as other tumors, but the examination of the sinuses is misleading as a typical appearance of the region involved can be seen only on a small film placed intra-orally.

BUMPUS, HERMON C., JR. Cystograms: Their clinical application and possible misinterpretation. *Surg., Gynec. & Obst.*, April, 1924, xxxviii, 546–549.

The cystogram serves as a valuable adjunct to the cystoscope, and if the possibility of its misinterpretation is appreciated may give information obtainable in no other way.

In making cystograms the bladder should be filled with one of the usual pyelographic fluids. Sodium bromide, 16 per cent, or potassium iodide, 12 per cent, may be used. The potassium iodide seems preferable, as at 12 per cent it is isotonic and casts a good shadow. These salts, however, have a slightly irritating effect, and in patients with much cystitis silver iodide emulsion, 5 per cent, is more satisfactory because of its mechanical qualities. After the bladder is filled the urethra should be compressed and the first picture taken directly above the symphysis, so that the outline of the bladder will be thrown clear of the sacrum. Two other pictures should then be taken with the roentgen tube tilted so that the first picture is projected to the right, and the second to the left. By this means diverticula near the base of the bladder, which might be obscured by the shadow of the bladder in pictures taken directly from above, are thrown so that their shadows fall along the periphery of the bladder and thus are brought into view. The fourth plate is taken like the first, the bladder having been emptied. This plate will disclose diverticula that do not drain, and also the amount of residual urine present, if the bladder first has been emptied by voiding.

Good cystograms will disclose diverticula of the bladder and of the urethra, false diverticula, tumors of the bladder and prostatic hypertrophy. Cystograms taken in the Trendelenburg position will disclose the presence of ureteral reflux. In pyelonephritis the apparently normal ureteral meatus is often incompetent. In 114 such cystograms, the reflux was observed in 21. In diseases of the central nervous system an atonic condition may affect the urinary tract, causing the appearance of reflux. In 70 cases of disease of the central nervous system which were examined by the cystogram, 7 had reflux of the ureters.

Carr, W. M. A case of hair ball. *Radiology*, September, 1924, iii, 257–259.

The roentgen-ray findings in the case reported were: a large, freely movable stomach containing a large freely movable mass. There was also a pouch on the greater curvature of the body of the stomach. The diagnosis was pedunculated benign tumor or hair ball. Operation disclosed a large hair ball.

Childs, Samuel B. Case report of a large fecalith. *Radiology*, September, 1924, iii, 261–262.

A barium enema was given to the patient, a woman aged forty. The roentgen film made shortly thereafter showed no irregularity or filling defects in the entire colon. After evacuation of the bowels a second film disclosed a large, dense mass with sharply defined contour. Its appearance simulated that of a very large bladder stone. Clinically there was no evidence of bladder disease, nor of fibroid, nor of calcified glands. The only other diagnosis considered was that of large fecalith. This mass was detached with difficulty but was too large for expulsion. It was crushed and the fragments were passed after a time.

Craver, L. F. The value of physical signs in the early detection of pulmonary metastases. *Am. J. M. Sc.*, June, 1924, clxvii, 852–863.

Just as in pulmonary tuberculosis, there is on the whole close correspondence between the roentgenographic or roentgenoscopic signs and the physical signs of metastases, although one or the other group may sometimes fail completely. A beginning dry pleurisy or tuberculosis or the remains of old infections increase the difficulties of diagnosis and roentgen interpretation. The early signs of metastases of breast carcinoma are more frequently discovered in the lower half of the chest posteriorly than at the apex and anteriorly. Metastases to the lungs from osteogenic sarcomas are usually first discovered roentgenologically before other physical signs appear. The earliest physical sign in metastases from breast carcinomas is a patchy limitation of the breath sounds particularly during inspiration.

Roentgen-ray interpretations were made independently of the clinical diagnoses in the following. Of 33 cases considered positive for metastasis from breast carcinoma, only 6 were frankly negative by roentgen-ray examination. Of 49 other cases with questionable physical signs, 26 were negative roentgenologically; and of 134 clinically negative cases, only 9 were frankly positive roentgenologically. In 15 cases of bone sarcoma suitable for this study, a similar close agreement was found between the physical signs in the chest and the roentgenological reports.

Eisendrath, Daniel N. Ureteropyelography (urography) in abdominal diagnosis. *Surg., Gynec. & Obst.*, May, 1924, xxxviii, 666–673.

One must be thoroughly familiar with the appearance of the roentgenograms taken in normal individuals lest serious errors in diagnosis be made. So-called "kinks" of the ureter are found so frequently where absolutely no other clinical symptoms are present that it is questioned whether the ureter may not be so redundant as to fold upon itself even with the kidney in normal location and not abnormally mobile. It is very easy to create an artificial

"kink" of the ureter with the catheter, so that the ureterogram should be made only with the catheter withdrawn entirely or in the lowermost portion of the ureter.

If a renal calculus is of branching character a pyelogram is hardly necessary as a rule, but it is of special value in the differentiation of shadows due to calculi in the gall-bladder, bile ducts or pancreas, as well as other extrarenal and ureteral shadows. If a suspicious shadow is covered by or "included" in the pyelogram the shadow is certainly due to a renal calculus. In some cases a lighter area corresponding to the calculus is seen. The recognition of a ureteral calculus is also important. At the point of lodgment of a ureteral calculus there is visible either a nodular widening of the ureter or a lighter area. At the same time one is able to confirm the diagnosis of a true intra-ureteral shadow by observing the degree of dilatation of the ureter above the obstructing calculus as well as dilatation of the renal pelvis itself.

It cannot be emphasized too strongly that pyeloureterograms should be taken in the recumbent and upright positions in obscure abdominal conditions for the purpose of determining accurately the degree of mobility and the presence of hydronephrosis due to ureteral obstruction from a kinked ureter in a movable kidney.

The most important data given by ureteropyelography alone or with the opaque catheter are: (1) displacement of the ureter inward or outward usually by a retroperitoneal neoplasm, either a sarcoma of the lymph nodes or neoplasm of the kidney itself or of the important adjacent structures; (2) filling defects or distortion in the form of elongation or compression of the renal pelvis and its calyces. The latter is a typical finding in intrarenal neoplasm but may occasionally occur in a perinephritic abscess.

GARDNER, BOYD S. A method of localizing roots of teeth, residual granulomas, or foreign bodies. *Radiology*, September, 1924, iii, 254–255.

A small piece of metal is fixed with adhesive tape in the approximate vicinity of the body to be located. This is then roentgenographed. A modified Boley gauge is used to measure the distance between the metal and the nearest tooth; or in edentulous mouths the gauge is used in the same manner but the measurement is taken from the frenum to the piece of metal.

HAMILTON, C. E. Disease of the mediastinum and its contents. *Am. J. M. Sc.*, June, 1924, clxvii, 888–899.

The roentgen-ray examination is invaluable in locating the structure within the mediastinum involved in the pathological process. Roentgenoscopy is more important than the plate examination because the patient may be observed in the various oblique positions, and pulsations, if any, noted. The esophagus should be studied with the aid of an esophageal paste. Lesions of the mediastinal glands usually appear as a bilateral mass with scalloped outer border at either hilus area. Bronchoscopy and esophagoscopy are useful aids in fixing the diagnosis in certain conditions. Some of the benign tumors and tumors involving the nerves are the only conditions within the mediastinum which may escape a definite diagnosis after careful physical, roentgenologic and laboratory examination.

MEYER, KEITH T. Report of two cases of calcified atheroma at the arch of the aorta. *Radiology*, September, 1924, iii, 250–253.

It is suggested that careful roentgenologic attention should be directed to the thoracic and lumbar aorta in order to determine evidences of increased visibility of the aorta in all cases of obscure abdominal and thoracic pain. In the 2 cases described deposition of calcium was only an incidental finding and of minor clinical import. Roentgen-ray examination is readily able to disclose sclerosis and degeneration with calcification of the aorta.

RENDICH, RICHARD A., and CONNORS, JOHN F. A study of the pressure hour-glass or cascade stomach. *Surg., Gynec. & Obst.*, June, 1924, xxxviii, 771–780.

This deformity results from the forward displacement of the more mobile portion of the vertical arm of the stomach by pressure exerted along the posterior wall. This pressure is more commonly caused by a distended splenic flexure, and less often by a neoplasm, particularly of retroperitoneal origin. This condition occurs independently of any organic lesion of the alimentary tract. The deformity is more striking in the roentgenogram when only a small amount of opaque mixture is administered. It is best visualized roentgenoscopically during ingestion in the vertical, anterior oblique posture. In its extreme degree the condition may be misinterpreted as true hour-glass stomach. When the cardial saccule is deep, it is sometimes mistaken for a diverticulum.

The following facts aid in differentiating organic from pressure hour-glass stomachs. In the organic hour-glass stomach constriction occurs of one or more borders; if but one, it consists of an indrawing of the greater curvature. Constriction usually is present in the pars media. There is no disturbance of the antero-

posterior relation of the locules. There is no disburbance of the lateral relation of locules except occasionally by adhesions. The gastric contour is irregular, and organic lesion is present. The appearance is more pronounced on administration of large quantities of mixture and the condition persists.

In pressure hour-glass stomach there is constriction only of the posterior wall, and only near the junction of the partes cardia and media. The lower locule is displaced forward and usually mesially. The gastric contour is regular and organic lesion is rarely present. The appearance is much less marked on distention of the stomach. The condition is nonpersistent, and the minor degree of this deformity may be absent on reexamination.

This condition was produced experimentally by filling the colon with air. The condition as described, excluding those cases resulting from neoplasms, represents a definite clinical entity and the treatment should be directed to the underlying cause, that is the colon, rather than the stomach.

SUTHERLAND, CHARLES G. Osteochondromatosis in the hip-joint: Report of a case. *Radiology*, October, 1924, iii, 285.

The patient was a boy, aged thirteen, who gave a history of injury to leg and hip due to falls. The physical examination was negative except for a slight limp. Roentgen-ray examination revealed multiple osteocartilaginous bodies within the hip joint. The characteristic feature in the roentgenogram of this condition is that of an intact outline of the joint surfaces. At operation, 31 osteocartilaginous bodies were removed from the cavity of the joint. They varied in size from 4 mm. to 1.5 cm. Convalescence was uneventful, and motion in the hip joint was free at the time of dismissal.

SUTHERLAND, CHARLES G. Report of case of giant colon with impacted feces in the sigmoid. *Radiology*, September, 1924, iii, 254–260.

A mass about 12 cm. in diameter was palpated in the right lower abdomen of a man aged twenty-three. The mass was smooth, rounded, putty-like and movable. Roentgen examination revealed marked dilatation of the distal portion of the large bowel with a filling defect in the sigmoid. A later roentgenogram showed the normal contour of the colon with a large central filling defect due to foreign body in the bowel. Preliminary dilatation of the rectum permitted the removal of large quantities of hard impacted feces. The patient was operated on to correct the condition. The descending colon was normal and there appeared no mechanical obstruction around the rectum to account for the enormous dilatation proximal to it. The pathologic report of the tissues was: "Giant colon with markedly thickened walls and multiple stercorous ulcers."

SWANBERG, HAROLD. Pleurisy of the hilum region. *Surg., Gynec. & Obst.*, April, 1924, xxxviii, 506–508.

Pleurisy of the hilum region can be successfully diagnosed only by a combination of careful history with roentgenologic study. Without a careful history, the increased hilum shadow might be interpreted as a mediastinal tumor, glandular masses or limited pulmonary lesions. Because of the extreme fetid odor such cases may be mistaken for pulmonary gangrene. However in the latter condition the fetid odor precedes expectoration. Stethoscopic signs are more important, and the general condition is more serious.

The case reported occurred in a man forty-two years old. The roentgenoscopic examination of the chest showed an irregularly shaped opacity in the right lung situated in the right hilum region, which could not be separated from the hilum itself but was not sharply defined. There was some lagging of the right diaphragm. After consideration of the clinical symptoms and the results of the roentgen examination, the conclusion reached was that this case was one of those comparatively rare conditions of pleurisy of the hilum region in the hilum open space of the pleura. They frequently rupture and empty into the bronchi causing a sudden appearance of purulent expectoration with extreme fetid breath.

WILLIS, THEODORE A. Backache from vertebral anomaly. *Surg., Gynec. & Obst.*, May, 1924, xxxviii, 658–665.

Though the human spinal column is the most stable of the primate columns, it still presents frequent variations from the modal type. These variations result from the evolutionary shortening of the column by cephalad progression of the pelvic girdle complex upon the column. The articulation of the girdle with the column is therefore a region of morphological instability as evidenced by the frequent occurrence of developmental anomalies. Spinal columns thus affected are predisposed to mechanical derangement, the symptoms of which are essentially ligamentous in origin.

The anomalies may be divided into two groups, one of which involves the last lumbar segment alone, the other affects the articulation between this segment and the first sacral. The former includes various types of interruption in continuity of the neural arch and

the atypical transverse process. The defect of the arch is responsible for the occurrence of spondylolisthesis and kindred disorders. The latter group comprises the abmodal developmental formations of the articular processes. Each group gives rise to definite clinical syndromes. The form of treatment and prognosis depends upon the individual case.

In the first group above mentioned it is necessary, for diagnosis, to make use of stereoscopic roentgen pictures or flat views from several angles. In the ordinary flat picture many of the transverse processes extending beyond the posterior limit of the ilia would appear to impinge upon these bones. In only 5 cases was there actual evidence of such bone contact. Diagnosis of the various types of anomaly is based ultimately upon the roentgenogram, but the signs of ligamentous injury are very suggestive. In the centrally split arch the partially sacralized lumbar, the impinging transverse process and the atypical articular process careful study of the stereoscopic roentgenogram may make the diagnosis clear. In the lateral laminar defect, the roentgenogram is not sufficiently definite except when the condition has progressed to a spondylolisthesis. The anteroposterior stereoscopic view was found the most satisfactory for diagnosis.

ROENTGEN AND RADIUM THERAPY

Burg, K. M. Treatment with radiothorium of a case of myeloid leucemia and complicating gastric carcinoma. *Deutsche med. Wchnschr., Berl.*, June 27, 1924, I, 881–882.

Injection of 200 E.S.U. of radiothorium caused a drop in the leucocyte count from 187,000 to 53,000 and a favorable alteration in the differential count. A second injection, a month later, caused a similar change. The radiothorium is supposed to exert its biological action on myeloid and lymphatic tissue, and in this case, it had the desired effect.

The patient was seen again 3 months later with symptoms of a gastric carcinoma which was treated with roentgen radiation. The blood picture no longer showed pathological leucocytes and the leucemic condition was absent. It is concluded that the leucemia was the primary affection because of absence of cancerous metastases in the spinal column.

Freund, Leopold. Roentgen-ray treatment of acute suppurations. *Wien. klin. Wchnschr.*, June 12, 1924, xxxvii, 596–597.

A review of clinical experience extending over many years shows that roentgen radiation in mild doses exerts a healing action on suppurative processes, but the effect is not usually permanent. Recidives apparently cannot be prevented.

It is believed that the radiation stimulates the normal functions so that they may better cope with invasion of foreign organisms. The suggestion of Pordes, that the radiation kills leucocytes which set free antibodies, appears to be untenable as an explanation of the action of the rays on suppurations.

Jerlov, Emil. Two cases of lymphangioma cysticum originating from the omentum healed with roentgen treatment. *Acta radiol., Stockholm*, August 25, 1924, iii, 354–366.

An account is given of 2 cases of cystic, multilocular lymphangioma originating from the omentum. The first case occurred in a man 42 years old, and the second in a woman of 30 years. Both were operated upon but in neither case could a complete removal be accomplished. Both cases received postoperative roentgen treatment filtered through 0.5 mm. Cu plus 1 mm. Al, 2 to 2½ ma., spark gap 35 to 39 cm., skin focal distance from 23 to 30 cm. An extraordinary and beneficial effect of the radiation was noted in the patients, both of whom are completely free from symptoms.

Arce, J., and Ivanissevich. Pre-operative roentgen sterilization of hydatid cysts. Bol. y Trabajos de la Soc. de Cir. de Buenos Aires, April 15, 1924, viii, 37.

In the institute of surgery of the University of Buenos Aires, the authors have made the following experiments on the sterilization of hydatid cysts prior to operation:

1. Tissue from a hydatid cyst was placed in a suspension under a cover glass and numerous scoleces with characteristic morphology and normal motility were observed.

2. At a second observation a preparation similar to the first was submitted for one hour to the action of a tube at 200,000 volts under the same circumstances as in the treatment of deep seated malignant tissues. At the end of the treatment the scoleces were almost totally disintegrated. They had lost their characteristic disposition and there was no sign of any movement whatever.

3. At a third observation a similar preparation from a sheep suffering from hydatid cyst of the liver, whose liver had been previously submitted to the same amount of radiation as in the second observation, showed that the scoleces were not disintegrated; but they were entirely lacking in motility.

In actual practice formolization and aspiration have been employed as the means of preventing secondary hydatidosis from opera-

tive transplantation. If the roentgen sterilzation gives equal or greater security from the point of view of technique, it will be a great advance.

BEETS, H. N., and ARENS, ROBERT A. Physical measurements and comparative technic in relation to biological dosage, *Radiology*, October, 1924, iii, 293–296.

The differences in the application of high voltage therapeutic radiation among various experienced roentgenologists have their source in the variety of roentgen-ray transformers, the filters and especially the tubes. It has frequently been noted that although the ordinary factors such as peak voltage, milliamperage, skin-target distance, filter and field were kept constant the time required to deliver an erythema dose has varied from one machine to another.

Eight high voltage transformers were studied as to their output under actual treatment conditions with an electroscope that was carefully checked. An iontoquantimeter was also used and found fairly consistent in its readings. The various machines showed a maximum deviation from the mean of 18.5 to 28.5 per cent in the "E" units per ma-min., and from 9.9 to 13.5 per cent in the total dose of "E" units.

Eleven different roentgen tubes were checked under as nearly identical conditions as possible. It was found that new tubes showed a minimum variation in mean output; while old tubes showed enormous differences in output. There seemed to be no apparent relation between the efficiency of the tube and its length of service. The condition of the target seemed to be the principal factor in its variation. It is stated that it is not possible to translate dosage by the usually accepted means, that is, peak voltage, milliamperage, skin-target distance and time, and that this practice is highly dangerous and should be discouraged.

JOHNSON, FREDERICK M. Radium treatment of carcinoma of the antrum. *Surg., Gynec. & Obst.*, June, 1924, xxxviii, 819–822.

Cancer of the antrum must be recognized in the early stage before any method of treatment will produce uniform and favorable results. Conservative surgery combined with radium promises to give better results than does the radical operation. Palliation of a large number of hopelessly advanced cases is possible through the conservative use of radium.

Successful application of radium depends on an adequate exposure of the area. As a rule the oral approach is best but if conditions demand, the eye should be removed and the floor of the orbit opened. The preoperative treatment consists in subjecting the antrum and accessory sinuses to irradiation from a pack at a distance of 6 cm. The pack is a flat brass box with walls 2 mm. thick and an area of 77 sq. cm. It contains silver capsules of glass emanation tubes. The dosage given is about 9000 mc-hr., which will produce a slight skin erythema. The lymphatic glands of the neck are exposed in the same way. The operative treatment involves essentially the exposure of the tumor mass so that it may be irradiated. Radium is applied by tying unfiltered emanation tubes in the end of an ordinary rubber finger cot and packing it centrally or toward any wall, depending on the needs of the case. As a rule, about 35 to 40 mc. are applied for periods varying from 48 to 60 hours. Postoperative treatment involves careful search for possible neoplastic nodules that were overlooked. If any such areas are present and appear to be enlarging emanation tubes or filtered needles are applied. However, caution should be used in order not to treat unnecessarily since experience has shown that regression may continue even though outward radium effects have disappeared.

A review is given of a series of 24 such cases, 12 in males and 12 in females. There was no improvement in 4 cases because they were hopelessly advanced; 4 cases showed satisfactory response to operative treatment; 8 cases were improved locally and generally although never free at any time from malignant growth. Four cases presented no clinical evidence of disease for a period of 1 to 5 years. Three cases failed to return for observation after 1 to 4 years, while the last case was free from disease for 6½ years and then showed a recurrence.

STEVENS, ROLLIN H. Facts and theories in cancer therapy. *Radiology*, October, 1924, iii, 286–292.

A general review of the situation showed that no treatment of cancer now known is satisfactory. The object in the treatment of deep-seated cancer should be the stimulation of resistance rather than administration of local lethal doses. We must now look to the biologist for the application of the modern knowledge of the physics of radiation in solving the many biological problems connected with cancer.

WILLIAMS, FRANCIS H. The use of radium radiations in the treatment of tonsils: A further report. *Am. J. M. Sc.*, July, 1924, clxviii, 18–34.

The treatment with radium may be so moderate as to produce no discomfort or so vigorous as to cause some irritation for a few

days. The dosage for an adult with 38 mg. of radium element is about 10 min. for the first dose for each tonsil with 0.58 mm. Al, or a somewhat longer exposure with 0.87 mm. Al. Subsequent doses should be smaller or larger as the conditions require, usually not over 15 to 20 min., the average number necessary being about 4 treatments at intervals of about 3 to 4 weeks. In cases where the tonsils are very large, longer treatment than that for the average case is desirable. For children, a good initial dose with 38 mg. radium element through 0.58 mm. Al is ordinarily 5 to 10 min. for each tonsil. For delicate children, one treatment of even 5 minutes' duration to each tonsil may produce such improvement in general condition, that such children will gain in strength and appetite although there may not be much change apparent in the tonsils.

A description is given of instruments useful in applying the radium and studying its effects. The radium container is made of gold and is provided with an aluminum cover.

A review is given of the results in 101 cases of faucial tonsils and 4 of lingual tonsils. These added to those previously reported upon bring the total to more than 200 cases that have been treated, the first of them more than 3 years ago, and from which no harmful results have appeared. Usually the symptoms have been very much improved, and if treatment was pursued there usually occurred complete relief. The method is of great advantage in those cases that are not good operative risks. In how large a proportion of the cases for which tonsillectomy is ordinarily advised radium should be used time and further experience will demonstrate. This method is also adapted to the treatment of lymphoid tissue in the pharynx, and in the region near the Eustachian tube in cases of ear trouble.

MISCELLANEOUS

PACKARD, C. Susceptibility of cells to radium emanations. *Biol. Bull. Marine Biol. Lab.*, 1924, xlvi, 165–177.

The susceptibility of *Paramecium* to radium radiations (chiefly the slowest beta rays) varies with the temperature at the same rate as do physiological reactions of various kinds. It also varies directly with the degree of permeability of the surface layer of the cell. The slowest beta rays act on the surface layer of the cell, increasing its permeability, and if allowed to act long enough they cause a typical cytolysis. In this respect, beta rays resemble other types of radiant energy and diverse chemical cytolytic agents. Cells which have a relatively high permeability are more susceptible than those with a low permeability, for the cytolytic action of the rays is quickly followed in the former by an irreversible cytolysis, while in the latter it is reversible. It is also suggested that this increase in permeability, following brief exposures, is the cause of the acceleration in division rate seen in *Paramecium* and in other cells and tissues.

REIMER, O. Roentgen ulcers. *Wien. klin. Wchnschr.*, July 10, 1924, xxxvii, 696–699.

The roentgen ulcer is a necrotic process in a tissue with extreme atrophic and degenerative changes throughout, including, especially, its vasculature. Ordinarily, conservative treatment, as opposed to surgical intervention, will produce granulation and healing, and this is illustrated in 5 cases. When, however, the ulcerative tissue shows definite signs of the development of pathologic types of cells, weak fibrinous masses of tissue and few, poorly-formed blood vessels, surgical removal becomes clearly indicated. Several such cases are described in detail. An important point to remember is that the tissue surrounding a roentgen ulcer is far from normal and unable to tolerate injections of local anesthetics which may delay and even prevent healing. Morphine should be given if necessary to allay pain in such circumstances.

WELS, P. Effect of roentgen rays upon the oxidation velocity of cells. *Arch. f. d. ges. Physiol. (Pflüger's)*, 1924, cciii, 262–273.

An exposure of several hours to roentgen rays did not alter the oxidation velocity of cells of several differing types, namely, avian erythrocytes, frog-muscle cells, yeast cells and *Staph. aureus*. With *Staph. aureus*, the reproductive rate was inhibited although the oxidation reactions were not impaired. This suggests that the growth inhibiting effect is not associated with the processes of oxidation.

WESTMAN, AXEL. A case of bismuth subnitrate poisoning with fatal issue following an injection of Beck's paste. *Acta radiol., Stockholm*, August 25, 1924, iii, 344–353.

Attention is called to the danger existing on injecting bismuth paste into serous cavities. An account is given of a fatal case of bismuth subnitrate poisoning following the injection of 75 c.c. of Beck's bismuth paste into an empyema cavity. The toxicological aspect is characterized by a grave stomatitis followed by a metallic margin around the teeth, profuse diarrhea which became bloody toward the end, icterus, epistaxis, and nephritis. These symptoms are apparently due to the bismuth. There were no signs of a nitrite poisoning.

GLASSER, OTTO. The Seemann spectrograph. *Radiology*, September, 1924, iii, 202–207.

A brief general description of the smaller type of spectrograph usually used in the treatment room is presented. The roentgen rays are so directed as to strike a rock salt crystal within a lead glass tube. A lead slit permits rays of only one wave length to pass and impinge upon a photographic plate. By means of clock-work arrangement the slit is moved regularly over the whole field.

The wave length distribution and to some extent the intensity of the different wave lengths can be determined by the spectrum thus obtained.

KEGERREIS, ROY. Apparatus for the calibration of x-ray machines. *Radiology*, August, 1924, iii, 141–144.

A description is given of a semi-portable testing apparatus for use in checking up roentgen machines in an institution. By means of a specially designed mechanism incorporated with the sphere gap, the adjustments can be easily made; and at the same time, the scale has been greatly enlarged and made linear. A temperature and pressure correction chart is given for the 12.5 cm. sphere gap. One standardized Coolidge tube is used for all the tests on the moderate voltage machines. The ionization current readings are taken by means of a portable microammeter connected to a battery and ionization chamber through a single socket and jack and a 30 ft. triple conductor concentric cable.

A small portable apparatus has been devised to check up the tube performance and output of installations as a whole. The entire apparatus is self-contained, the ionization chamber is in the top part of the case while the lower part contains a microammeter with a switch board type scale and the necessary batteries. The apparatus functions with either side up, thus making it possible to take measurements either from above or below. Only one range is provided in the microammeter but distance, aperture, or filter variations can be used to adapt it to any machine. The same kind of a set-up has been adapted to the measurement of ionization from radium tubes. The accuracy is not so high but is well within the range demanded by this type of biologic therapeutics.

MENVILLE, L. J. Experimental work bearing upon the standardization of the absorptive powers of the x-rays by salts of the various metals. *Radiology*, August, 1924, iii, 118–127.

A tabulation is given of the absorptive powers of the elements in the order of their atomic numbers. The values were computed by multiplying the cube of the atomic number by the density of the corresponding element.

A large number of metallic salts solutions were examined for their relative absorbability. They were placed in open No. 10 gelatine capsules and roentgenographed together with a comparison scale built up of layers of tinfoil. On this scale, No. 1 consisted of one sheet of tinfoil 0.0005 in. thick, No. 2, of 2 such sheets, No. 3 of 3 such sheets, etc. The roentgenograms were taken under the following constant conditions: 35 ma., voltage 5½ in. back up, target-tube distance 30 in., time, 6 sec. The comparison of the shadows cast by the various compounds (as salts or in solution) with the shadow scale was made direct from the film with the aid of a colorimeter, and the results are tabulated. A brief summary of the toxicity of some of the elements is included.

It is stated that the absorbability of a compound is the sum of the absorbabilities of its component atoms, so that the absorptive value may be computed from the data given for the individual chemical elements.

POYNTZ, LOUIS K. A new Bucky stand. *Radiology*, September, 1924, iii, 228–230.

An old Kelley-Koett type G table was cut down to the proper size to support the Bucky diaphragm which was bolted on. The advantages claimed for this arrangement are: (1) allows the making of Bucky plates in vertical, horizontal or intermediary positions; (2) it can be readily adjusted to a given area or patient; (3) allows for the demonstration of fluid levels; (4) it is mechanically simple, rugged and not costly. It can be easily adjusted and can duplicate positions or angles. It is labor-saving and also eliminates danger of breakage of the diaphragm through unnecessary handling.

ROWE, EDWARD. A compact x-ray treatment unit. *Radiology*, August, 1924, iii, 158–160.

A plan and illustrations are given of a unit, the chief factors of which are:—central control station made safe for the operator; a central compartment for the transformer and other unsafe, unsightly and noisy equipment; an arrangement whereby short wave-length equipment is safe for the patient and operator. The transformer room is in the center with the treatment rooms distributed around it, and the operating booth is so placed as to give clear view through lead glass of the treatment rooms.

SCHMITT, W. Roentgen treatment and offspring. *Klin. Wchnschr.*, July 22, 1924, iii, 1358–1360.

Observation of 9 pregnancies in 6 women disclosed but one still-birth (at 4 months) and

no abnormalities in the placenta or fetus. The mothers had previously been given roentgen radiation to produce temporary amenorrhea in treatment of myoma, etc. Reexamination of the surviving infants showed nothing unusual that could be ascribed to an effect of the roentgen rays. Further evidence that roentgen irradiation is not injurious is given in 2 cases of sterility in women, which were corrected by mild irradiations.

A review of the literature shows 130 pregnancies observed, 86 following roentgen irradiation and 44 following radium treatment. Thirty-six pregnancies ended in abortion, but complicating carcinomas and myomas were largely responsible for the high percentage of abortions. It may be stated, in general, that abnormalities in children due to irradiation of the ovaries of the mothers have not been established so far as this investigation shows. The relatively few abnormalities that did occur might just as well have occurred in children from untreated mothers. Continued observation and long experience are needed to give the final answer to the question.

Wilson, R. T., and Johnson, J. B. A study of the lymphatic system in its relation to high voltage x-ray therapy. *Radiology*, September, 1924, iii, 240–245.

Knowledge of the exact location of the terminal lymph vessels is a prerequisite to efficient irradiation. The distance separating malignancies from the terminal vessels is the distance from the blood stream. A brief review is given of the more common elements of the lymphatic system in order to recall the unusual routes that cancer may take at times and to disclose, if possible, some anatomical reasons why the progress of malignancy may be checked in some localities and not in others. The lymph vessels are most active in the young, less active or practically closed in adults, therefore all malignancies are more dangerous in the young. The glandular fields of the head and neck extend from the auricular and occipital regions to the clavicle of the breast, from the clavicle to the ensiform and from the axillary fold to the opposite breast. The cervix and uterine field are continuous from the symphysis to the first and second lumbar vertebrae. The fields all extend over a distance of more than 6 inches in most individuals. Experience has shown that a square opening of 20 to 30 cm. is necessary for adequate dosage of certain areas.

Clark, W. L., Morgan, J. D., and Asnis, E. J. A preliminary report on a modified x-radiation technic. *Radiology*, October, 1924, iii, 273–284.

Clinical observations supported by histologic findings indicate that the normal reactions in the surrounding healthy tissues may be aroused by rather small doses of roentgen radiation. These small doses, frequently repeated, appear to initiate the tissue reactions and also to continue them, while at the same time the healthy tissues remain uninjured. The object of the method described is that of causing the cancer cells to be surrounded with a sufficient number of leucocytes and to maintain the supply by a continued body reaction. The results reported in this preliminary study show that it is possible to bring about this physiological response of the normal tissues surrounding the cancer without the usual dangers of skin burn or radiation sickness.

The dose factors employed were: 220 kv., 4 ma., 50 cm. distance, large portals with cross fire, and filters of 0.75 mm. Cu and 1 mm. Al. For superficial lesions treatment was given twice a day for 3 min. Deeper lesions received a 10-min. exposure once or twice a day.

Soon after the beginning of these treatments nearly all patients volunteer the information of feeling better and relief from symptoms. This was followed by shrinkage in size of tumor and in a softening of its constituents. A section taken at this time showed marked small round-cell infiltration. A section taken somewhat later showed vacuolization of the cancer cells, loss of cell outline and staining power and beginning of hyalinization.

In the 7 cases discussed there was definite evidence that stimulative roentgen radiation as opposed to destructive treatment utilized the host's body defenses and is capable of yielding satisfactory results.

Trostler, I. S. The Granger mask for Waters' position. *Radiology*, September, 1924, iii, 260–261.

The modification of the Granger mask consists in adjusting the angle to 45° by means of a heavy wire. The results are stated to be satisfactory and uniform.